APPENDIX G

Air Quality Technical Materials

San Francisco Bay Area Environmental Management Plan

June 1978

This plan was prepared by the Association of Bay Area Governments with a grant and other assistance from the Environmental Protection Agency, in cooperation with Bay Area Air Pollution Control District, Metropolitan Transportation Commission, San Francisco Bay Regional Water Quality Control Board and Counties of the Bay Area with assistance of these agencies: ■ Army Corps of Engineers ■ California Air Resources Board ■ California Department of Health ■ California Department of Transportation ■ Council of Bay Area Resource Conservation Districts ■ Governor's Office of Planning and Research ■ Lawrence Berkeley Laboratory ■ Lawrence Livermore Laboratory ■ San Francisco Bay Conservation and Development Commission ■ State Water Resources Control Board ■ State Solid Waste Management Board ■ Wastewater Solids Study

ABAG

AIR QUALITY MAINTENANCE PLAN

LIST OF TECHNICAL MATERIALS

BACKGROUND

- "Summary of the Air Quality Maintenance Plan Work Program for the Bay Area Joint Technical Staff," November 1976.
- "History of Air Quality Planning in the San Francisco Bay Area," February 1976.

AQMP/TECHNICAL MEMORANDA

- Technical Memorandum 1 - "Base Year Selection and Technical Assumptions," September 1976.
- Technical Memorandum 2 - "Projections/Forecasting: System Description and Technical Assumptions," December 1976.
- Technical Memorandum 3 - "Air Quality Past and Present," March 1977.
- Technical Memorandum 4 - "Status of Existing Controls Related to Air Pollution," March 1977.
- Technical Memorandum 5 - "Candidate Control Measures," April 1977.
- Technical Memorandum 6 - "The AQMP: Legal Requirements," July 1977.
- Technical Memorandum 7 - "Development and Analysis of Alternative Air Quality Strategies," July 1977.
- Technical Memorandum 8 - "Summary of the Technological Forecast for Motor Vehicle Emission Control," July 1977.
- Technical Memorandum 9 - "Summary of Technology Forecast for Organic Solvent Emissions," July 1977.
- Technical Memorandum 10 - "Summary of Technology Forecast Questionnaire: Combustion Sources," July 1977.
- Technical Memorandum 11 - "Present and Projected Air Pollutant Emissions in the San Francisco Bay Region," August 1977.
- Technical Memorandum 12 - "Baseline Motor Vehicle Emission Inventory: Methodology and Results," August 1977.
- Technical Memorandum 13 - "Benefits of Photochemical Oxidant Control," December 1977.
- Technical Memorandum 14 - "Effectiveness and Costs of Alternative Air Pollution Control Programs," September 1977.

- Technical Memorandum 15 - "Assessment of Air Pollution Control Programs," January 1978.

- Technical Memorandum 16 - "Institutional, Legal and Financial Requirements for Implementing Proposed Air Pollution Control Programs," September 1977.

- Technical Memorandum 17 - "Baseline LIRAQ Air Quality Projections," September 1977.

- Technical Memorandum 18 - "LIRAQ Emissions Sensitivity Analysis," September 1977.

- Technical Memorandum 19 - "Applicability of Selected Statistical/ Empirical Techniques to Air Quality Analysis in the San Francisco Bay Region," September 1977.

- Technical Memorandum 20 - "Procedure for Interpretation of LIRAQ Air Quality Projections," September 1977.

- Technical Memorandum 21 - "Geographical Distribution of Emissions from Non-Major Point (Area) Sources," October 1977.

- Technical Memorandum 22 - "Regional Travel Projections for AQMP," November 1977.

- Technical Memorandum 23 - "Evaluation of Transportation Control Measures," November 1977.

- Technical Memorandum 24 - "Analysis of Suspended Particulate Matter in the San Francisco Bay Region," November 1977.

- Technical Memorandum 25 - "Evaluation of the Transportation System Needs in the Compact Land Use Alternative," January 1978.

AQMP/ISSUE PAPERS

- Issue Paper 1 - "Air Quality Modeling for the San Francisco Bay Region," September 1976.

- Issue Paper 2 - "The Air Quality Modeling Process: Accuracy and Related Issues," May 1977.

- Issue Paper 3 -"Regional/Local Issues in Land Use Controls for Improving Air Quality," September 1977.

AQMP BRIEFS

- Environmental Management Program, "Air Quality Maintenance Plan Brief No. 1 - The Goal, Future Decisions, Issues and Organization," March 1977.

- "Air Quality Maintenance Plan Brief No. 2 - Alternative Air Strategies," June 1977.
- "Air Quality Maintenance Plan Brief No. 3 - Air Quality Problems," August 1977.
- "Air Quality Maintenance Plan Brief No. 4 - Progress Report on Development of the Air Quality Maintenance Plan," October 1977.

SUMMARY OF THE
AIR QUALITY MAINTENANCE PLAN WORK PROGRAM
for the
BAY AREA JOINT TECHNICAL STAFF

November, 1976

Association of Bay Area Governments
Bay Area Air Pollution Control District
Metropolitan Transportation Commission

with assistance from

U.S. Environmental Protection Agency
California Air Resources Board
California Department of Transportation

Air Quality Maintenance

The air quality problems of the Bay Area are well documented and generally recognized by its inhabitants, as well as those local, regional, State, and Federal agencies responsible for its control. While significant progress has been made towards controlling the sources of air pollutant emissions, ambient air quality continues to frequently exceed established air quality standards. Furthermore, projections estimate violations of these standards will continue into the foreseeable future given existing trends in land use development and population growth in the region.

Achievement of the national ambient air quality standards as required by the Clean Air Act of 1970 and State standards will necessitate even more controls than those currently in existence or scheduled for implementation. This portion of the work program is a part of the ongoing air quality planning activities directed towards attainment and maintenance of clean air for the Bay Area.

BACKGROUND

In 1970, the Amendments to the Clean Air Act were passed. Under Section 110(a)(1) of this Act, the states were given primary responsibility for developing and submitting to EPA state implementation plans (SIP) which contained measures to demonstrate attainment and maintenance of the national ambient air quality standards. The Air Resources Board (ARB) is responsible for developing California's SIP. The first California SIP (State of California, 1972) was found to be deficient by EPA because it did not include adequate control strategies for attaining air quality standards.

As a result of several court suits, EPA required California (and a number of other states) to submit a Transportation Control Plan (TCP) to correct some of the inadequacies of the SIP. Because of the enormity of the task and the short amount of time available, the State defaulted on its responsibility and EPA was forced to promulgate a TCP in several regions, including the San Francisco Bay Area. The TCP proposed by EPA for the Bay Area included gas rationing to achieve air quality standards (TRW, Inc., July 1973).

Shortly thereafter, the State exercised its option to prepare its own TCP. The California Department of Transportation (Caltrans) was given primary responsibility to prepare various California TCPs; responsibility for the TCP for the Bay Area was delegated to the Metropolitan Transportation Commission (MTC). MTC and Caltrans completed a TCP early in 1975 directed toward short-term measures that could be implemented by 1977, the date for compliance with national ambient air quality standards (Metropolitan Transportation Commission, 1975).

A court order (Natural Resources Defense Council v. EPA, 1973) led to an EPA requirement for the identification of air quality maintenance areas (AQMA), areas that have the potential for long-term air pollution problems. The San Francisco Bay Area was identified as an AQMA in June 1974 by the ARB (State of California, 1974) and in September 1975 by the EPA (40 Fed. Reg. 41941). EPA regulations require the development of an Air Quality

Maintenance Plan (AQMP) for each AQMA. The AQMP will consider land use and transportation planning measures as well as programs for strict enforcement of stationary source and other technical controls.

In mid-1975, the California Air Resources Board (CARB) established the Bay Area Air Quality Maintenance Plan-Policy Task Force (AQMP-PTF)[1], and initiated Phase I of the air quality maintenance planning process. The proposed two phase planning process is directed at development and implementation of an AQMP for the region.

Phase I is to identify air quality problems and develop a work program to guide the Phase II planning efforts. The more substantive Phase II effort will develop a regional air quality strategy for achievement of the clean air objectives. Thus, the results of Phase II will be the region's response to federal requirements for an AQMP (40 Federal Register 49048).

With the formation of the Environmental Management Task Force (EMTF), composed of a diverse number of public and private representatives from the Bay Area, the AQMP-PTF adopted a resolution in its January, 1976 meeting which led to the integration of the 208 and AQMP planning programs:

> "Resolved, that the Phase I Policy Task Force hereby transfers the responsibility for completing Phase I of an Air Quality Maintenance Plan,. . . to the Environmental Management Task Force,. . . and. . . upon acceptance of said responsibility by the Environmental Management Policy Task Force, the Phase I (AQMP) Policy Task Force will immediately cease to exist."

In addition to accepting responsibility to prepare an AQMP in its charge, the EMTF formally resolved to accept all previous AQMP-PTF responsibilities at its second meeting.

The air quality portion of the work program which follows is intended to direct the Phase II air quality maintenance planning process. It will guide the preparation of a San Francisco Bay Area AQMP over the next two years. The tasks in this part of the work program are those directly or indirectly related to air quality impact assessment, and thus eligible for funding under the 208 program. These tasks are patterned after the initial AQMP-PTF efforts (Air Quality Maintenance Plan-Policy Task Force, 1976).

OBJECTIVES

The objectives of the AQMP are both numerous and ambitious. In summarizing the basic objectives of the AQMP program, the important points to be remembered are given below.

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[1]The AQMP-PTF was composed of thirty-five representatives of local and regional governments, in addition to a wide variety of other Bay Area interests -- conservation, business, industry, development, etc.

Integrity of the AQMP

Numerous concerns have been voiced both publicly and privately that the integrity of the AQMP program would be lost or its relative importance severely diluted in a comprehensive environmental management program. To allay these concerns, a number of measures will be taken to ensure certain independent analyses of air quality problems. To date, development of the AQMP work program has been as an identifiable and integral component of the overall 208/AQMP work program. Throughout the conduct of the air quality work, a joint air quality planning team will focus on addressing the air quality issues. This team will coordinate with the other environmental staff to ensure internal consistency of the technical analysis. As the various plans are developed and strategies evaluated, it will be necessary for the various environmental staffs to work even closer to ensure that intermedia impacts have been adequately addressed and that the separate functional area control strategies can be coordinated and integrated to achieve the mandated environmental objectives. A real advantage to the proposed approach is the opportunity to bring the difficult environmental trade-off and decision-making process before a single policymaking body representative of the diverse regional interests. If nothing else, such a process will eliminate the frequent "after-the-fact" environmental bartering which takes place to argue against often needed environmental programs.

Coordination of Regional Air Quality Planning

A variety of air pollution planning activities is conducted in the Bay Area by different agencies. In addition to ABAG, the more active agencies are the EPA, CARB, MTC, CALTRANS, and BAAPCD. To avoid duplication of these planning activities, the AQMP will coordinate all air quality planning efforts and serve as a focal point for linking these efforts to the environmental management program. A means to assist in this coordination will be formation of a joint technical staff with representatives from the affected regional agencies. Memoranda of understanding are being prepared among the agencies participating in this joint technical team concept.[2]

Achievement and Maintenance of Air Quality Standards

As required by the Clean Air Act of 1970, the alternative control strategies to be developed through the planning process will demonstrate achievement and maintenance of promulgated national and State ambient air quality standards. The main emphasis of AQMP will be control strategies for photochemical oxidants, total suspended particulates, sulfur dioxide, and carbon monoxide. It should be noted that federal and State standards differ in a number of ways--averaging times, concentration levels, and specific pollutants. For differences in concentration levels and averaging times, the more stringent standards will be applicable (in most cases, this is the

[2]Resolution adopted by the AQMP-PTF in January, 1976: "To facilitate the formation and support of this joint staff group, interagency arrangements such as memoranda of understanding... are encouraged."

federal standard). California has adopted a number of standards for pollutants which are not covered by federal standards. Specifically, the CARB has air quality standards for lead, sulfate, hydrogen sulfide, ethylene, and visibility reducing particulates. The extent of AQMP involvement for these pollutants will be very limited and dependent on existing data and information available for each pollutant. It is anticipated this will vary considerably.

Pollutants for which only State standards exist will be addressed as follows: the AQMP will summarize the problem, aerometric data (if available), sources of the problem, and potential control measures for reducing the quantity of the emissions generated. Projections of future air quality for these pollutants are not planned because the state-of-the-art analytical procedures for conducting such analysis are not well developed. Similarly, the analysis of institutional and financial mechanisms for carrying out these potential controls will not be examined in the AQMP. Where appropriate, recommendations will be prepared for future research on these pollutants.

Due to pending changes in the Clean Air Act and the severity of the Bay Area's air pollution problems, the specific time tables for achievement of these standards is uncertain. An underlying premise of the AQMP will be development of strategies for achievement of standards as expeditiously as possible result from the program and the diversity of agencies responsible for the implementation of the controls.

Throughout, substantial efforts will be devoted to development of realistic and workable implementation programs. To aid local governments, procedures and/or guidelines for local and regional adoption of the AQMP will be prepared. Clearly, another major objective of the AQMP will be development of mechanisms for a continuing AQMP planning process.

References

Air Quality Maintenance Plan-Policy Task Force. January, 1976. Preliminary Air Quality Maintenance Plan (AQMP) Work Program.

Metropolitan Transportation Commission. March 12, 1975. Proposed Transportation Control Plan for the San Francisco Bay Area Air Quality Control Region.

Natural Resources Defense Council v. EPA. (D.C. Cir. 1973). 4ERC 1945, 475 F. 2d 968.

State of California, Resources Agency, Air Resources Board. January 30, 1972. The State of California Implementation Plan for Achieving and Maintaining the National Ambient Air Quality Standards - Revision 5.

TRW, Inc. July, 1973. Air Quality Implementation Plan Development for Critical California Regions: San Francisco Bay Interstate AQCR. Prepared for Environmental Protection Agency.

40 Federal Register 49048. 1975.

40 Federal Register 41941. 1975.

PROCESS AND SCHEDULE

Development of any work program requires identification of tasks to be completed, the relationship between tasks, and constraints placed upon the program (e.g., time, budget).

The AQMP portion of the work program has five major components:

- Description - Tasks which describe the past and present air quality conditions.

- Prediction and Analysis - Tasks which forecast the air quality implications of future scenarios; these scenarios will range from alternative land use and transportation plans to a variety of specific control strategies.

- Impact Assessment - Tasks which analyze the economic, social, and environmental impacts of the alternatives forecast previously.

- Plan Formulation - Tasks which, based upon all the previous technical analyses, assist the decision-makers in formulating an AQMP for air quality improvement. Included in the plan formulation are tasks to develop and prepare an implementation program.

- Plan Adoption - Tasks to disseminate the AQMP to the public and local governments; also, tasks to assist in the adoption and implementation programs as needed -- guidelines, technical assistance, etc.

Implicit throughout the entire process is the assumption that public participation, intergovernmental coordination, and public information efforts will be undertaken. Furthermore, it is understood that the planning process does not start at time "zero," since it is currently ongoing, nor does it stop at two years when the program formally ends -- it is intended to be a continuing planning process.

INTEGRATION OF THE AQMP AND OTHER MANAGEMENT PLANS

The integration of air quality maintenance planning with other environmental programs occurs at many different places within the work program. The level or degree of integration varies considerably and may involve:

- Coordination and information exchange

- Interfacing of the technical assumptions and analyses

- Combining of similar tasks required of separate functional area programs

Throughout the conduct of the work program, the extent of integration will be dictated by several pragmatic concerns:

- Operational efficiency
- Avoidance of duplicating planning efforts
- Consolidation of planning support services
- Focused program and project management structure

Given the most ambitious attempts to fully integrate the environmental management programs, there are clearly work tasks which must be done separately for each functional area. Thus, although the extent of integration is influenced by "workable" program management concerns, the ultimate criteria for work tasks integration will be the requirement for sound technical analysis. It is neither the intent nor the philosophy of the program to use integration of the environmental plans to dilute the efforts of achieving each functional area's objectives. Instead, integration is seen as enhancing the opportunities for developing acceptable environmental management plans. More specifically, development of an AQMP within the context of a regional environmental management element is seen as offering the greatest potential for ultimate AQMP adoption and implementation.

A description of how the various AQMP tasks will be integrated with the other environmental tasks is provided below. The discussions have been organized around the five major AQMP work program components.

Description

The description component deals with describing historical and present air quality conditions. Tasks in this portion of the work program will largely be done independent of other environmental tasks. The main exception is selection of the "base year" which needs to be coordinated with other management plans, primarily for purposes of facilitating data collection in a consistent manner.

Prediction and Analysis

Much of the input data required for forecasting future air quality requires close coordination with tasks developing alternative land use and transportation plans. Common data bases for population, land use, and other demographic statistics will form the basis upon which the environmental (including air quality) baseline conditions will be defined.

In a similar fashion, future alternative land use and transportation scenarios will be projected for all environmental programs to consider. Thus, integration of this component will occur primarily through specification of uniform baseline and future conditions. By and large, the translation of these conditions to environmental quality by functional area requires separate and independent analyses. For example, once the baseline and future conditions are defined, the air quality implications of the alternatives can be analyzed. The analysis may or may not be related to other media

analyses. At a minimum, however, frequent information exchange is envisioned to provide overall direction and guidance to all the analysis tasks.

Impact Assessment

The overall work program proposes a single impact assessment framework for all management plans to be developed. This assessment framework will address all environmental problems and involve both local and regional interests. The impacts to be analyzed will be social, economic, political, and environmental.

The evaluation criteria to be established will provide a common denominator upon which subsequent plans and proposed programs can be uniformly judged. All interested parties and potentially affected agencies will have an opportunity to provide input to the evaluation criteria to be used in the impact assessment process. With respect to achieving air quality objectives, it should again be noted that federal mandates do not permit "tradeoffs" in the attainment and maintenance of standards, but do allow flexibility in the time tables deemed necessary to accomplish the goals.

The overall assessment process will be a focal point for evaluating all impacts from the management plans developed. Thus, it serves as a focus for environmental tradeoffs which may be required. This portion of the AQMP program will be fully integrated with the other management planning efforts.

Plan Formulation

Following a fully integrated assessment process, the plan formulation component will focus mainly on air quality considerations. As other environmental strategies are formulated, a range of alternative AQMP strategies will likewise be evaluated. Coordination and information exchange between programs will be required but due to the diverse nature of problems being addressed, substantive integration of the separate plan formulation tasks is neither desirable nor readily accomplished. Even if certain control tactics or strategies were to be recommended to achieve multiple environmental goals, the AQMP will need to be prepared as a separate and distinct plan to facilitate its subsequent submittal to the California Air Resources Board.

Plan Adoption

Integration of the AQMP adoption process with other management plan adoption procedures is possible to a limited extent. At the local level an integrated adoption process will be utilized, with cities and counties being requested to approve and adopt the Environmental Management Element to the Regional Plan. At the regional level, single purpose agencies or special districts would be more likely to approve specified management plans. For example, it is anticipated that BAAPCD and MTC would approve the AQMP, due to their required involvement in air quality planning activities.

Throughout the planning process other tasks will be conducted in an integrated fashion. For example, it is envisioned the public participation, public information, and intergovernmental relations aspects of the program will be conducted in an integrated manner. Lastly, internal project management and provision of necessary support services will be focused in order to facilitate efficient and effective conduct of the study.

PARTICIPANTS/DIVISION OF AGENCY LABOR

The AQMP is to coordinate air quality planning activities for the region. Due to the divergent mandates and responsibilities of the agencies involved in air quality planning, the AQMP program requires active participation by a number of agencies. The AQMP program is envisioned as a cooperative planning effort with clear specification of agency labor and shared responsibility among those agencies involved.

To this end, the AQMP-PTF adopted a resolution encouraging formation of a "joint technical staff" to conduct development of the AQMP. To facilitate formation of such a team, memoranda of understanding or joint powers agreements were recommended. At a minimum, the joint technical staff was to be represented by ABAG, BAAPCD and MTC.

As part of the work programming efforts and in an attempt to further define the respective agency roles and levels of involvement in development of an AQMP, the following progress has been made in organizing a joint technical staff:

- CARB - Working arrangements have been made for direct participation and support by the CARB in developing the AQMP. Other CARB staff will continue to review and monitor work progress and serve in a general liaison role. Both types of involvement will be funded by EPA directly through the CARB's annual operating grant (Section 105 of the Clean Air Act).

- BAAPCD - A Memorandum of Understanding with ABAG has been finalized facilitating BAAPCD involvement in the joint technical staff. The BAAPCD will provide technical assistance in many areas of the AQMP development.

- MTC - Work is underway to renew the existing Interagency Agreement for cooperative planning efforts. The update would address MTC involvement in the environmental management program, including the AQMP.

- CALTRANS - CALTRANS has indicated a Willingness to participate in the AQMP planning process. Specific details on level, extent, and type of involvement are yet to be determined.

The basic philosophy behind the "joint technical staff" approach is to utilize the best available personnel (regardless of agency representation) and resources to undertake the AQMP preparation. The approach is designed to

promote synergism by drawing upon a wide spectrum of technical and planning expertise. The involvement of key regional agencies in the planning process will also ensure that the respective agency interests are represented throughout.

SCHEDULE FOR TASK COMPLETION AND IDENTIFICATION OF AGENCY ROLES

The task completion schedule as previously indicated for each task is summarized in Exhibit 1 for the complete AQMP work program. As may be seen from this summary schedule, a variety of efforts will be proceeding on a parallel basis, thrus requiring a great deal of coordination. Exhibit 2 is a more detailed chart indicating specific work items for which each participating agency will have primary responsibility. Several arrows are included in the chart to indicate key outputs which serve as inputs to another agency's task; the full range of interaction anticipated and necessary for proper AQMP development cannot however be realistically shown on the chart. To summarize, the Bay Area Air Pollution Control District will assume lead responsibility for the development of baseline emission inventories, air quality modeling projections, and evaluation of stationary source control options. The Metropolitan Transportation Commission will assume lead responsibility for baseline transportation system forecasts and evaluation of transportation control options; and the Association of Bay Area Governments will develop the population, employment, and land use projections which will form the basis of the BAAPCD and MTC projections. In order to facilitate the coordination of the remaining AQMP tasks with the specialized expertise provided by both BAAPCD and MTC, as well as the coordination of the AQMP with other elements of the ABAG Environmental Management Plan, ABAG will assume the lead role for all remaining tasks including strategy development, plan formulation, integration, and adoption. Technical review and guidance for the AQMP is being provided by a Technical Advisory Committee (TAC) nominated by the Public Participation Committee of the Environmental Management Task Force. Membership of this TAC is shown in Attachmnet C.

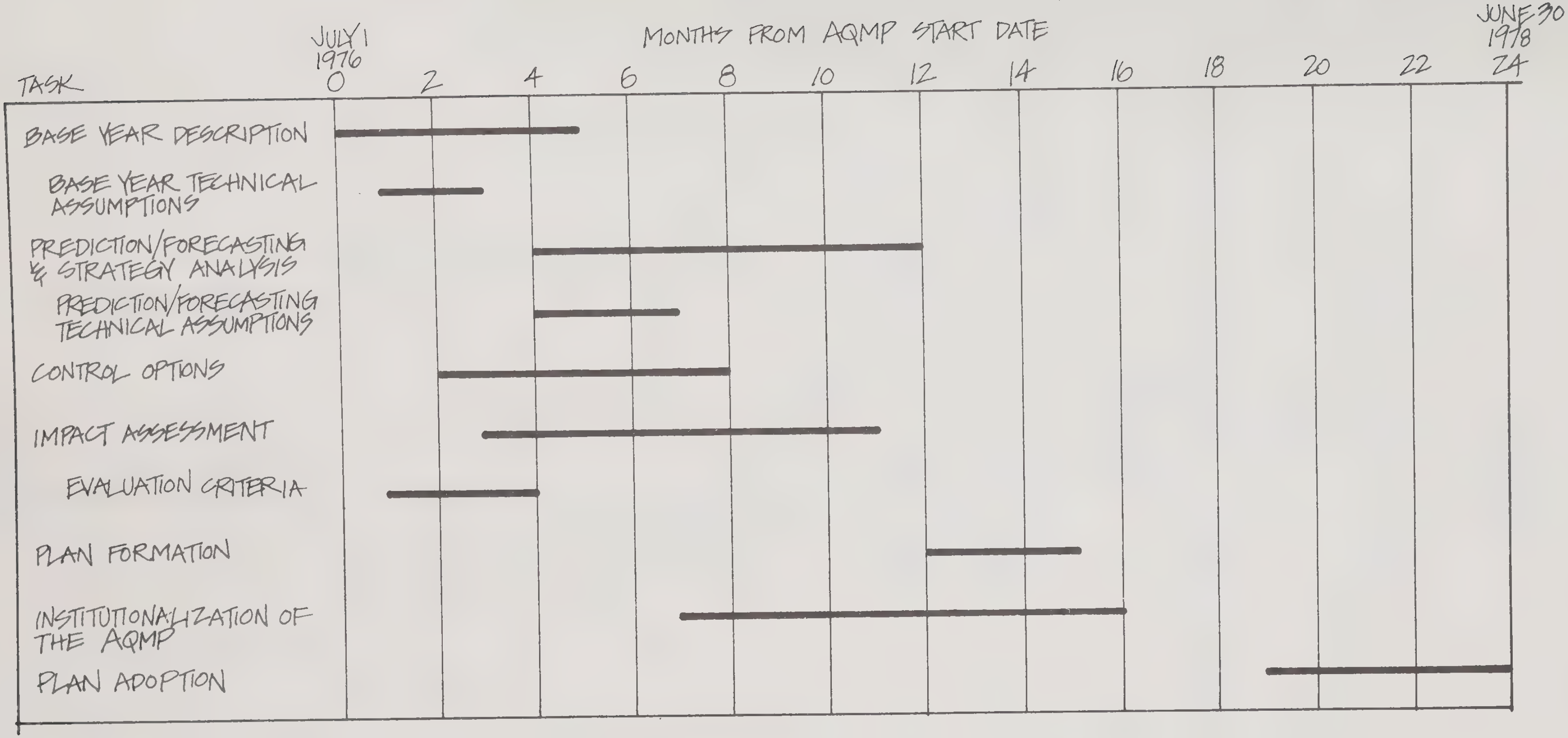


EXHIBIT 1 - PRIMARY AQMP TASK SCHEDULE

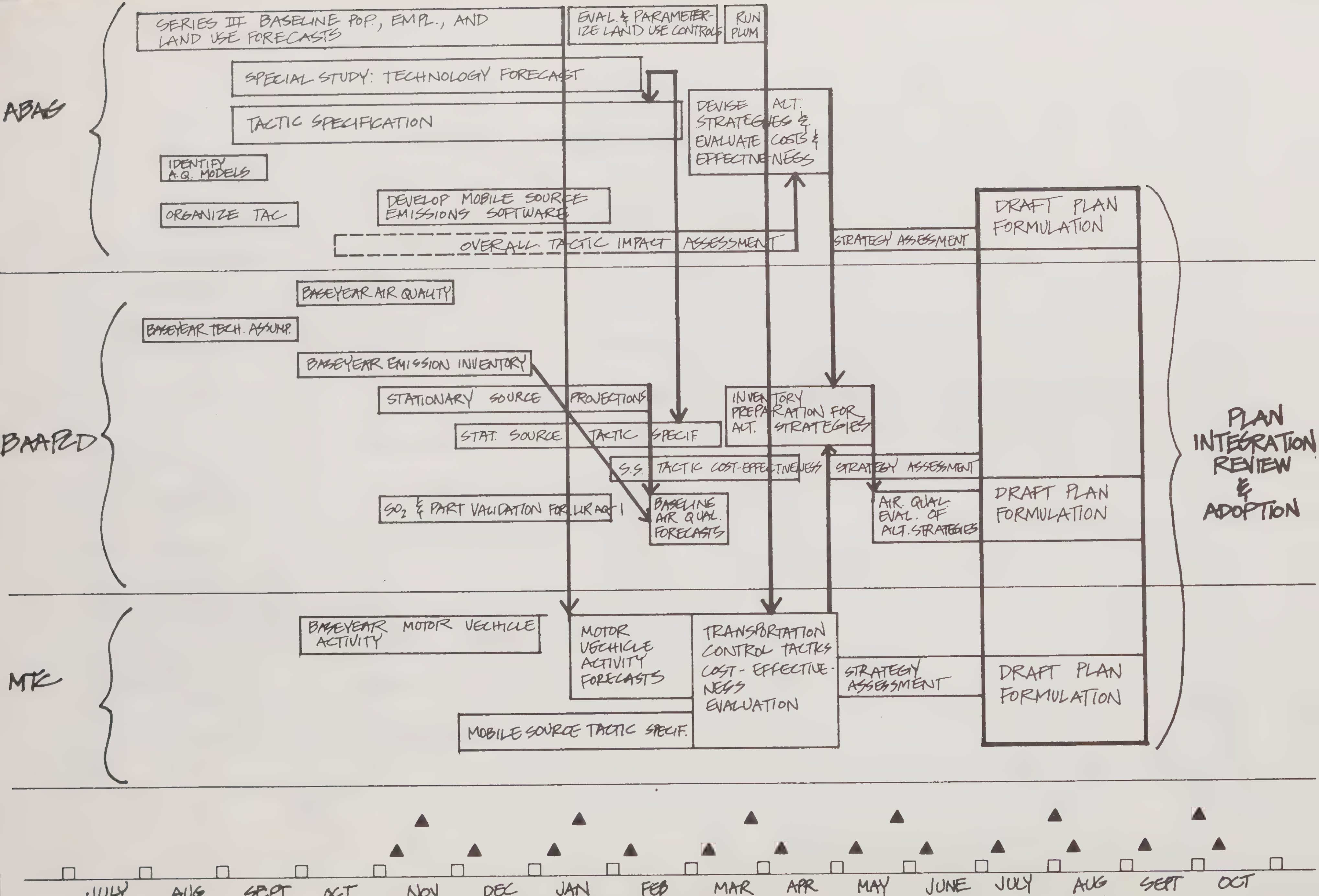


EXHIBIT 2 - SPECIFIC TASK ALLOCATION BY PARTICIPATING AGENCY

HISTORY OF AIR QUALITY PLANNING IN THE SAN FRANCISCO BAY AREA

.....A background paper

ABAG ASSOCIATION OF BAY AREA GOVERNMENTS

February 1976

History of Air Quality Planning in the Bay Area

In the early 1950's various groups in the San Francisco Bay Area became increasingly concerned with the Bay Area air pollution problem. At the same time, extensive investigation by an Assembly joint subcommittee indicated that, unlike the appropriateness of county or unified air pollution control districts for which enabling acts did exist, a regional strategy should be developed because of the peculiar geography of the region. The subcommittee proposed the creation of a single air pollution control district within the nine-county Bay Area. In 1955, legislation was passed which created the Bay Area Air Pollution Control District (BAAPCD) -- the first regional agency dealing with air pollution to be formed in the nation. District structure, operating procedures, and authority are contained in Divisions 20 and 26 of the California Health and Safety Code.

Unlike counties or unified districts, the BAAPCD has the power to tax; the District's tax rate is set by the State Legislature. The jurisdiction of the BAAPCD, like that of other air pollution control districts, is largely limited to policing non-vehicular sources of air pollution, primarily industry and burning (generically classified as "point" sources).

The District has adopted and enforces a number of regulations governing existing and proposed stationary sources.[1] These regulations constitute the

[1]Embodied in the procedures and regulations adopted by the BAAPCD and published in their "Rules and Regulations"

District's control strategies, and have resulted in substantial reductions in pollutant emissions. "Regulation Two" directly controls particulate matter (smoke and dust), sulfur dioxide, lead, nitrogen oxides, odorous substances and incinerator emissions. "Regulation Three" affects the formulation, storage, shipment and use of such materials as solvents, paints, gasoline and ink.

Air pollution control in the Bay Area during the 1950's and early 1960's was typical of most areas throughout the State. The air pollution control districts (APCDs) remained the level of government with direct control over polluting activities. The APCDs were concerned primarily with stationary sources and relied heavily on technological controls to reduce pollutant emissions.

During the late 1960's, coincident with increasing nationwide environmental awareness, the State and federal governments both recognized that the existing control efforts were not sufficient and local efforts would need to be supplemented. In 1967, the California legislature, in the Mulford-Carrell Act, established the Air Resources Board (ARB) to deal with the State's air pollution problem. The ARB has authority over motor vehicle emissions, including responsibility for motor vehicle emission standards and certification of devices for the extensive California-used car retrofit program. Another ARB function is to review, evaluate and change (if necessary) local air pollution control district programs. While "primary" responsibility for stationary sources (including enforcement of state standards) remains with

the APCDs, the State can and does provide overall guidance to the APCDs in their ongoing programs in an attempt to improve air quality.

During the same time period the California Air Resources Board was established the federal government responded to increasing public concern with air pollution throughout the country by enacting the Air Quality Act of 1967. This legislation provided for a national program to control automobile emissions and for vigorous support of State and local programs to control air pollution from stationary sources. Interest in air pollution control at all levels of government increased during the late 1960's and numerous shortcomings of the 1967 legislation were identified.

By the early 1970's air pollution control became a major federal concern with the passage of the National Environmental Policy Act (NEPA) of 1969, the Clean Air Act Amendments of 1970, and formation of the Environmental Protection Agency (EPA) in 1970. The 1970 Amendments to the Clean Air Act refined and expanded the federal government's role in air pollution control.

Under this Act, states were primarily responsible for developing and submitting to EPA a state implementation plan (SIP), which contained measures to attain promulgated national ambient air quality standards (established to protect public health and welfare). If a state failed to submit a SIP which was acceptable, EPA was given the authority to prepare such a Plan.

Responsibility for developing and updating California's SIP rests with the Air Resources Board. In the San Francisco Bay Area, the ARB directed the BAAPCD

to prepare various air pollution control strategies as part of the initial SIP. Based on these controls and others added by the ARB, the State of California submitted its SIP to EPA in February 1972, and EPA approved it, with certain exceptions, in May of 1972. One of the deficiencies of the California SIP was that it did not include adequate control strategies for transportation related pollutants -- in particular, carbon monoxide and photochemical oxidants. This particular deficiency was common in many SIPs around the nation.[2]

Subsequent to a court decision on this issue, EPA directed the appropriate states (which included California) to submit a Transportation Control Plan (TCP) for the auto-related pollutants. The purpose of the TCP was to develop control strategies which would lead to a reduction in transportation related pollutants sufficient to allow attainment of air quality standards. Among the ways this was to be accomplished were reducing the number of vehicle miles traveled (VMT) and more extensive controls on in-use vehicles, e.g. retrofit, inspection-maintenance.

The deadlines for submission of the TCPs were very short. For example, on March 20, 1973 the EPA Administrator, acting in response to a court order, notified the Governor of California that a TCP for the San Francisco Bay Area should

[2]Emphasis on transportation controls was predicated by the Act's requirement that SIPs include, "emission limitations, schedules, and timetables for compliance with such limitations, and such other measures as may be necessary to insure attainment and maintenance of such primary or secondary standard, including, but not limited to, land-use and transportation controls".

be submitted by April 15, 1973. The tight deadlines, combined with the severe air pollution problems to be dealt with, contributed to the State repeatedly defaulting on its responsibility to prepare an "acceptable" SIP.

When California failed to submit a TCP as requested, EPA promulgated its own TCP for the State in November 1973. The Plan indicated that a 97% reduction in the VMT in the San Francisco Bay Area would be necessary to achieve the standards set by the Clean Air Act. The EPA plan included traffic controls, other mobile source emission controls and extensive stationary source controls. In order to achieve the 97% reduction in VMT, limitation on gasoline sales, e.g. gas rationing, was proposed. While EPA expressed serious reservations about the feasibility of a gas rationing program, it stated the Clean Air Act left the EPA Administrator with no other legal alternative but to include such a strategy.

Recognizing the unsatisfactory nature of the EPA plan, the State exercised its option to prepare and substitute its own TCP. While the California Department of Transportation (CALTRANS) was the State agency designated to prepare the State's overall TCP, the development of a local TCP for the Bay Area was delegated to the Metropolitan Transportation Commission (MTC) --the Bay Area's regional transportation planning agency.

The TCP was developed under the direction of the MTC Traffic Coordinating Council (TCC). The membership of the TCC is structured to represent the diverse interests of the Region: a representative appointed by the Board of

Supervisors of each county; a representative appointed by the Council of Mayors of each county; and one representative each from MTC, CALTRANS, the California Highway Patrol, the Metropolitan Transit Association, the City of San Jose, the City of Oakland and the City of San Francisco. MTC and CALTRANS completed the TCP in early 1975, which MTC then adopted as part of the Regional Transportation Plan. Various transportation control strategies, short and long term, are presented in the TCP with a basic analysis of their implications on air quality. However, the initial development of the TCP was directed towards short term measures that could be implemented and effective by 1977, the date for compliance with national ambient air quality standards.

As an element of the TCP, a Parking Management Plan (PMP) was required in the San Francisco Bay Area.[3] The PMP was to be used to supplement and complement the public transportation and carpooling measures. The approach taken by MTC in preparing a regional Parking Management Plan was to develop a set of guidelines which clearly identified parking related strategies which are implementable on the local level. MTC is nearing the completion of its study to develop these guidelines. Even though the Federal requirement has been suspended, the region's cities can use the guidelines in preparing their "local" parking plans.

[3]The EPA suspended indefinitely its parking management regulations in July 1975, awaiting guidance from Congress in the forthcoming Clean Air Act Amendments.

More recently, another requirement of the SIPs is inclusion of a long term air quality maintenace plan (AQMP) for sustained maintenance of clean air objectives once attained. As part of this longer term strategy, EPA proposed the review of indirect sources of air pollution.[4] "Indirect sources" are traffic-inducing facilities such as shopping centers, industrial parks, schools, airports, etc. These facilities do not emit air pollutants directly, but indirectly result in pollutant generation by stimulating travel. Indirect source review examines the effects on air quality of the traffic and associated automotive emissions caused by these facilities. The adoption of this land use control followed a similar pattern to the development of transportation controls. First, EPA required the states to develop indirect source review regulations and when most of the states defaulted (including California) EPA promulgated indirect source review regulations for those states without them.

In the Bay Area, the BAAPCD extended its permit procedure[5] to include indirect sources prior to the date EPA's Indirect Source Regulations became effective. However, the District withdrew its indirect source review requirements with the suspension of EPA's regulations less than a month later.

Just as the TCP was required by court order in those areas that were not expected to attain air quality standards by the 1977 deadline, similarly a

[4]Like the parking management regulations, the EPA has suspended the indirect source review regulations pending Congressional guidance.

[5]Adopted in 1972, the permit system is for new or modified sources. Under this system, a permit must be denied if it is determined that a facility would either not meet emission requirements or cause or exacerbate a violation of an ambient air quality standard.

court order led to the identification of air quality maintenance areas (AQMA) as areas that are not anticipated to achieve or maintain national ambient air quality standards over the long term. The San Francisco Bay Area was identified as an AQMA in June 1974 by the ARB and designated as such by the EPA in September 1975. EPA's regulations require development of an Air Quality Maintenance Plan (AQMP) for each designated AQMA; the AQMP is to be submitted as a revision to the SIP. Air quality maintenance requires a comprehensive control strategy approach to the long term air pollution problems of a region. By necessity, it is anticipated such an air pollution program will include land use and transportation control measures, in concert with the rigorous application and enforcement of technological controls on stationary sources and the automobile.

The ARB is currently guiding the California efforts to develop AQMPs and revise the SIP to demonstrate both attainment and maintenance of air quality objectives. To determine how the air quality maintenance planning process would proceed, the ARB organized a Phase I Air Quality Maintenance Plan Policy Task Force (AQMP-PTF)[6] in each AQMA in California. The San Francisco Bay Area Policy Task Force met for the first time in September 1975. The AQMP-PTF, a body composed of elected officials and representatives of various organizations in the Bay Area, was accorded the leadership role in recognition of the fact that local involvement and support is essential to development of an implementable and acceptable AQMP. This was done because of

[6] The Phase I PTF had formal charges to: 1) examine the air quality problems of the San Francisco Bay Area Air Basin; 2) develop an initial AQMP Policy framework; 3) review various air quality improvement strategies for the Phase II planning process; 4) recommend an appropriate institutional framework to develop and implement an AQMP; 5) identify resources for the Phase II planning process; and 6) develop and approve a Phase II program.

the anticipated impacts of the control strategies on how fundamental decisions about the location, extent, timing and costs of areawide growth and development are made. Only local government can make and implement most of these decisions. Both the ARB and EPA concur that a goal of air quality maintenance planning will be to attain a high degree of local government involvement and responsibility.

In January 1976, the Bay Area Phase I AQMP-PTF completed preparation of a "Preliminary Air Quality Maintenance Plan (AQMP) Work Program." This work program is designed to direct the Phase II AQMP program development and planning efforts, and result in an overall regional air quality strategy for achievement of clean air objectives. The results of Phase II will serve as the region's response to federal requirements for an AQMP and should provide excellent guidance to decision-makers in the region.

At the same time that the AQMP-PTF completed its preliminary work program, it adopted unanimously a resolution which transferred the responsibility for completing Phase I of the AQMP to the Environmental Management Task Force[7]

[7] In May 1975, the Association of Bay Area Governments (ABAG) was designated as the "areawide waste treatment management planning agency" for the Bay Area under Section 208 of the Federal Water Pollution Control Act Amendments of 1972. The next month ABAG was awarded a $4.3 million EPA grant to prepare a plan to meet the requirements of Section 208, which is part of a national program to meet clean water goals set by Congress for 1983. A fundamental concept underlying the San Francisco Bay Area's 208 effort is that it is an environmental management program and not just a water quality planning process. Water resources, air quality and solid waste planning are to be integrated into the 208 process. In following this concept, ABAG's Executive Board created the Environmental Management Task Force (EMTF) to guide the preparation of an environmental management element of the Regional Plan. ABAG used the composition of the Phase I AQMP Policy Task Force as a model for representation on the EMTF.

of the Association of Bay Area Governments (ABAG). In turn, the Environmental Management Task Force (EMTF) adopted a resolution to accept all previous AQMP-PTF responsibilities in January 1976.

With this merger of the air and water pollution control policy groups, the only local policy body in the country that is responsible for development of the areawide wastewater management plan required under Section 208 of the Federal Water Pollution Control Act Amendments of 1972 and the Air Quality Maintenance Plan prepared under the Clear Air Act has been established. The development of both the 208 plan and the AQMP will be a local/regional process with State guidance and federal support.

BASE YEAR SELECTION AND TECHNICAL ASSUMPTIONS

TECHNICAL MEMORANDUM NO. 1
SEPTEMBER, 1976

The base year selection and technical assumptions are an important part of any air quality planning effort. To a large degree, these assumptions are the foundation upon which the technical analysis is based. This technical memorandum is divided into two main sections. Section I presents the rationale for selecting a base year, with a preliminary recommendation that 1975 be adopted for this project. The base year technical assumptions are discussed separately in section II.

I. Base Year Selection - The selection of a base year is important for several reasons. First, a given base year infers the use of data generally available for that year. Thus, data used for future years should be directly comparable to the base year data. The base year serves as a reference point for developing a future baseline and alternatives. Procedures used to calculate base year data must be acceptable for repeated use in future scenarios, so that results can be compared on a consistent basis. For example, the methods used to collect, generate, organize, and smooth base year data should be carried through for future years, so that output differences are not artificially caused by a switch in methodology. In summary, the specification of a base year will have an impact on the scheduling, costs, and ultimate success of the AQMP.

There are two general approaches for selecting a base year. The first approach is to specify a convenient year--perhaps the present year or a year that ends in zero or the year of some important event--and then proceed to collect and develop all the data required for the project model input. The second approach requires a survey of data already available (and potentially available), and the choice of a base year on the basis of the most complete available data set. This second alternative, of course, can provide substantial savings in time and money through efficient use of existing resources. The first alternative, on the other hand, provides greater freedom and perhaps immediacy, because it allows arbitrary choices of time scale and methodology for data collection. Associated cost and delays may be prohibitive, however.

The data itself, regardless of the base year selected must be complete, consistent, accurate, and of sufficient detail for the task at hand. Table 1 presents a comparison of 1973 and 1975 data for base year alternatives. The mobile source inventory, stationary source inventory, and the LIRAQ model are considered separately for each year. Comparisons were made on the basis of availability, consistency, accuracy and sensitivity. Sensitivity, in this case, means the ability of a system to respond to an input change. The system may be the LIRAQ model itself, or the programs used to generate mobile and stationary inventories.

In comparing 1973 and 1975, the second-stated general approach to base year choice was used--i.e., a survey of resources already available. This approach is required for the AQMP project, because to embark on a new data collection program would be extremely time-consuming and costly. In the 1973/1975 comparison (see Table 1) both years score generally high in consistency, accuracy and sensitivity. 1973 has a slight edge in consistency, but a major advantage is data availability. While the 1973 data are immediately available for both mobile and stationary sources, the 1975 mobile source data would not be available until approximately December 1976. The 1975 stationary source data is now available, but would require moderate work to specify temporal and spatial distributions.

In selecting either 1973 or 1975, minor inconsistencies in existing data would need to be worked out. On the whole, while 1975 appears to require the most staff efforts initially (and could result in a several month project delay), it has been tentatively selected as the more appropriate base year for AQMP. Selection of 1975 is anticipated to have longer run benefits, especially as the baseline and control strategy alternatives are developed.

II. Base Year Technical Assumptions - A number of technical assumptions must be made to organize the base year source inventory and to execute the air quality models. This section describes the basic technical assumptions for the source inventory. Base year data will be projected to future years to represent baseline or "existing trends" conditions. From the projected baseline, alternative control strategies will be developed. To the extent possible, an internally consistent set of data and technical assumptions will be used. These data will be used in the air quality models for testing the effectiveness of alternative control programs.

A. Source Inventory - The source inventory provides information on source emissions and defines the location, frequency, duration, and relative contribution of the emissions. The success of any air quality model heavily depends on the availability of an accurate inventory. The inventory must include all pollutant sources--mobile, stationary, and area.

Emission rates must be specified for relatively short time intervals and moderately small geographical areas--typically one or two kilometers (or miles) square. Detailed temporal and spatial distribution of emissions is essential to the model input. Spatial distribution is needed to determine downwind air quality maximum for reactive pollutants resulting from non-linear transport, diffusion, and chemical transformations. The temporal distribution of emissions is essential to predict the peak hourly average.

Table 1. COMPARISON OF ALTERNATIVE BASE YEARS FOR THE AQMP

Alternative Base Year	Data Availability	Consistency	Accuracy	Sensitivity
1973	M - 1973 HWY network & load file readily available.	Generally consistent with MTC's future travel models.	1973 travel pattern model has been calibrated with actual ground counts. All traffic data were provided by the MTC and the output evaluated by the MTC staff. Relatively accurate.	Good
	S - 1973 stationary inventory is available by 1x1 km. grid square. However, minor modification may be required (e.g., SO_2).	Consistent	Distribution of non-major point sources may require some refinements, particularly organics.	Good
	L - LIRAQ model has been executed with 1973 as the base year. All model input data for 1973 are available.	Consistent	Expectation very high; has been calibrated for several days.	Very good
1975	M - 1975 HWY network & load file expected within 2-3 months.	Consistent	Not currently available. However, expectation is high.	Unknown; expected to be good.
	S - 1975 stationary inventory is available. Temporal and spatial distribution of emissions are required.	Consistent	Expectation high with more detailed source categories than 1973.	Unknown; expected to be good.
	L - Minor modifications to LIRAQ required. Minor model tuning may be required.	Slightly inconsistent (i.e. 1973 Met. data used with 1975 Emission inventory data).	Expectation high.	Expectation very good.

Legend: M - Mobile Source Inventory; S - Stationary Source Inventory; L - LIRAQ Model

Since LIRAQ was designed to yield hourly average pollutant concentrations with spatial resolution of 1 km or more, the source inventory needs to provide emission rates on an hourly basis with a spatial resolution of 1 km. To be complete, the source inventory must include five major pollutants, hydrocarbon (HC), nitrogen oxides (NO_x), carbon monoxide (CO), sulfur dioxides (SO_2), and particulates.

1. Mobile Source Inventory - Emissions from motor vehicles are a substantial portion of most air contaminants. The air pollution models for the San Francisco Bay Area rely heavily on the ability to quantify air pollutants arising from motor vehicle activity. Therefore, reliable estimates of existing and future mobile source emissions are critical inputs for the air quality study.

Total emissions from motor vehicles in the region are a function of the vehicle emission factors and the vehicle miles traveled (VMT). Variables such as regional vehicle mix by age, type, make and deterioration rate, as well as average speeds by road type, constitute major factors used to develop regional vehicle emission factors. Calculation of regional VMT by road type is also a necessary input for development of a regional mobile source inventory. Therefore, development of a mobile source inventory for the AQMP will be based on methodologies and procedures for estimating VMT and emission factors:

- Estimation of Vehicle Miles Traveled - VMT can be estimated by several alternative methods, based on a) travel data from transportation models; b) motor vehicle fuel consumption; or c) vehicle registrations. The most accurate method known to date is the transportation modeling procedures. Therefore, the basic methodology for mobile source inventory for the AQMP will be based on travel pattern modeling procedures. This method involves a highway link system from which VMT are calculated as a function of individual link length and average daily traffic (ADT) volume on the link.

- Estimate of Emission Factors - The quantification of air contaminants generated by motor vehicles in a specific region depends substantilly on the availability of empirical data characterizing emission rates as a function of various aspects of the regional vehicle population and transportation patterns. Because vehicle emission rates depend on such a great variety of factors (i.e., type of vehicle, condition of vehicle, driving habits, traffic flow, temperature, vehicle load, etc.), accurate functional determination of these rates is extremely involved.

  Since the beginning of the vehicle emissions surveillance testing in 1971, the Environmental Protection Agency (EPA) has been steadily accumulating emissions test data to support advance emission modeling techniques. In December 1975 the EPA published the final report of Supplement No. 5 to the Compilation of Air Pollutant Emission Factors (AP-42) describing these advanced techniques. Based on the EPA's AP-42 Supplement No. 5, with few modifications, the Air Resources Board (ARB) developed the mobile source emissions program EMFAC3.

ARB's EMFAC3 will be used for mobile source emission factors for the AQMP. However, a number of variables, which vary with geographical location and estimation situation, can affect emission estimates considerably. The variables of concern include average vehicle speed, percentage of cold vehicle operation, percentage of travel by vehicle category, and ambient temperature. Therefore, it is necessary for the AQMP to develop localized emission factors reflecting the above variables as a modification to EMFAC3.

Figure 1 presents a schematic flow chart for the 1973 mobile source inventory developed for LIRAQ. Minor modifications to this schematic will be needed in the AQMP to handle the latest emission factors and estimation procedures.

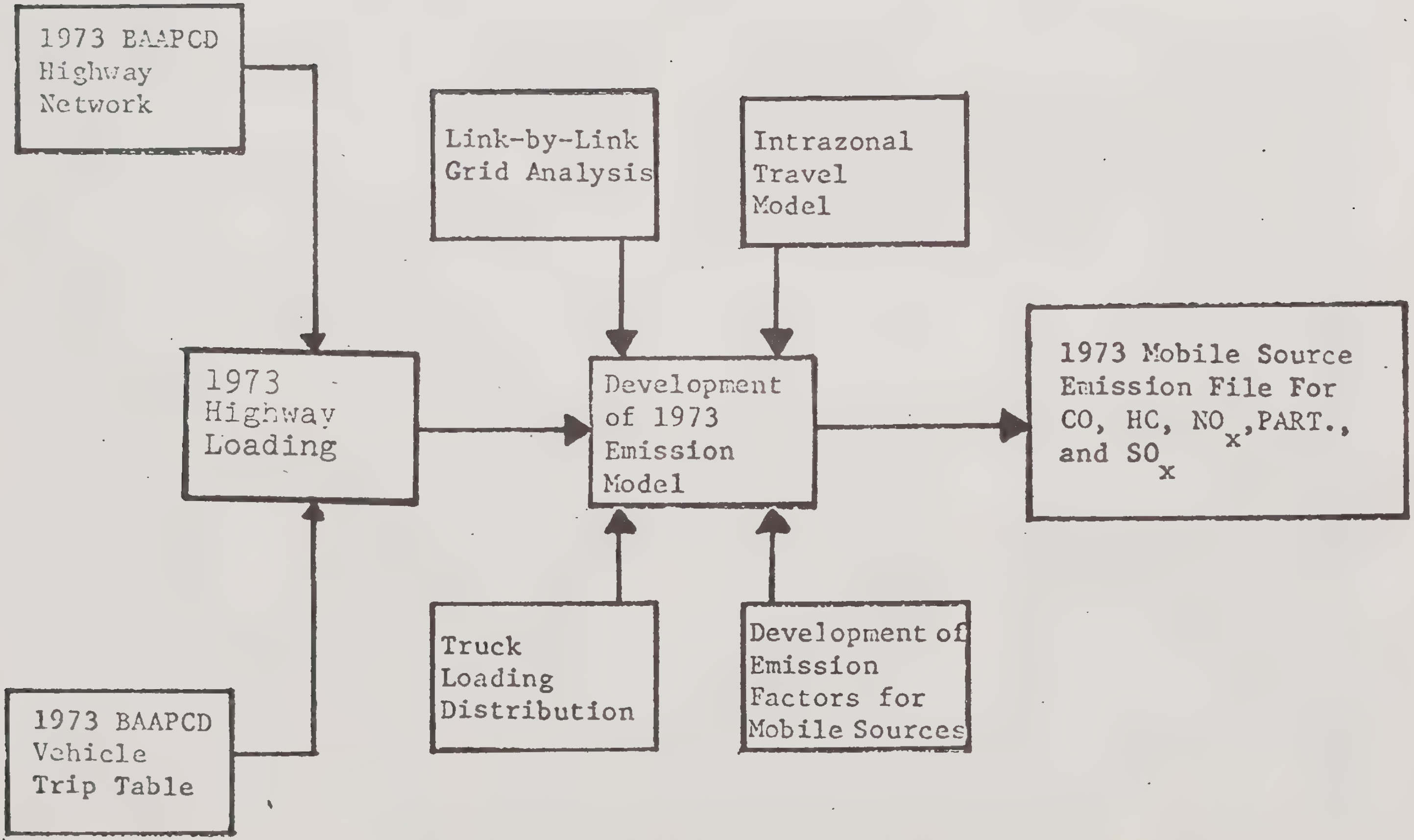
2. Stationary Source Inventory - Emissions from stationary sources are the second major component of a source inventory. In compiling the stationary portion of the inventory, emissions are usually broken down by source category, equipment category, type of industry, company or some combination of these items. In general, there are three approaches to preparing a stationary inventory: 1) all sources treated as area sources, 2) major point sources separated out and treated individually, and 3) all point sources separated out and treated individually.

The first approach is a simple and cost-effective method. However, the accuracy of this method suffers from uncertainty in assigning "activity coefficients" as well as from the assumptions made when applying a general emission factor to a variety of actual sources. Also, this method has a severe limitation in its inability to distribute geographically the emissions from significant point sources. The second approach is similar to the first except that very large point sources are geographically located and their emissions are calculated utilizing specific "activity coefficients" and when possible, specific emission factors. An inventory prepared following this approach has improved accuracy and at least partial distribution of its emissions into the geography of the air basin. The EPA is currently using this approach in its National Emissions Data System (NEDS) inventory.

The third approach is the most accurate, provides the best geographical distribution of emissions, and most expensive. The Bay Area Air Pollution Control District (BAAPCD) utilizes this method for their annual emissions inventory. Implementation of this method, however, yields benefits extending beyond emission inventory preparation. Other activities of the control agency such as the evaluation and issuance of permits, and enforcement action against regulatory violations, can be tied directly to the point source information system and utilize a common data processing system. The expenditure of agency resources in the third approach, therefore, can be shared by various beneficiaries within the control agency.

Regardless of which of the three approaches described above is used in compiling an emission inventory, the inventory will list average emissions for a fixed unit of time--a year, a season, a month, or perhaps even a day. The shorter the averaging period, the more data and/or technical assumptions which must be made to generate an appropriate inventory. The data required for a single day's inventory is such that the resouces available for such a task become a severe constraint. For modeling applications, the inventory's

FIGURE 1 FLOW CHART FOR 1973 BAAPCD MOBILE SOURCE INVENTORY



inability to present the dynamic, temporal emission rates of the real world is a serious shortcoming. The EPA and ARB prepare annual inventories. The BAAPCD prepares monthly inventories, perhaps the shortest base time currently used in source inventory preparation. In the BAAPCD inventory, all major point sources are listed separately and distributed source emissions are compiled by county.

For the stationary source inventory, the following baseyear technical assumptions are made:

- The BAAPCD's Emissions Inventory will be used for developing the base year stationary source inventory for the AQMP. However, better methodologies and procedures to distribute non-major point sources into the grid system based on relationships between functional activities and source strengths should be formulated.

- The inventory must reflect the reactivity classification of organic compounds adopted by the ARB.

2. Air Quality Model - The base year selection has been evaluated within a frame of reference that foresees a large part of the modeling being LIRAQ runs, particularly for oxidant and CO. The expected heavy use of LIRAQ reduces the base year selection problem to considerations of accepting an existing (1973) base year data library or building new libraries for a later year, say 1975. Technical validity, cost, consistency, and deadline times are all factors which constrain the possible decisions.

LIRAQ is an Eulerian (grid-based) model, i.e. it deals with scalar and vector fields of physical quantities at particular instants of time. This is in contrast to dealing with the trajectories of particular material points or parcels of a Lagrangian model. LIRAQ transforms these fields from one time step to the next according to a particular partial differential equation, the vertically averaged continuity equation, and a set of ordinary differential equations representing the photochemistry.

Because LIRAQ operates on fields, it requires extensive emissions and meteorological libraries to serve it. These data sets and the manner in which they are generated and modified are described in detail in Volumes 1 and 2 of "Development of an Air Pollution Model for the San Francisco Bay Area" and the "User's Guide to the LIRAQ Model." Suffice it to say that fairly elaborate subroutines have been coded at LLL and transferred to LBL to generate and regenerate these libraries.

Meteorological data for selected periods in 1973 and 1974 have been assembled by LLL, and according to Dr. MacCracken, this data can be accessed with relative ease, should additional verification days for LIRAQ be desirable. Data for 1975 apparently have not been collected, and a significant additional effort would be required to assemble it. (During the development of LIRAQ in 1973, special instrumented aircraft measurements were made to provide a more complete meteorological data base. This data was combined with data collected by BAAPCD, Caltrans, and the National Weather Service.)

PROJECTIONS/FORECASTING:
SYSTEM DESCRIPTION AND TECHNICAL ASSUMPTIONS

The Air Quality Maintenance Plan for the Bay Area is intended to be a long range plan for attainment and maintenance of air quality standards. The technical foundation for the plan rests upon the techniques used to project future air quality. Given the wide variety of human activities which give rise to air pollution, any projection of future air quality must account for changes in these activities as well as changes in the technology for air pollution control. The number of variables potentially affecting future air quality is staggering, and their interactions are in many cases beyond our current understanding. Nevertheless, the major forces shaping future air quality in the region are known and at work today. Decisions made now can and will affect the future, and it is to our benefit to bring the greatest possible amount of information to bear on these decisions.

It is with this philosophy that the rather elaborate forecasting system described here has been selected to provide the technical basis of the AQMP. The system incorporates the most advanced forecasting techniques currently available, and relies heavily on the computer as the tool for keeping track of the multitude of variables and interrelationships involved.

Before proceeding to a description of the forecasting system, it should be understood that no system or tool regardless of its size or complexity can predict the future. Rather, the system will forecast the most reasonable air quality result of a series of alternative events. The decisions to be made as part of the AQMP will influence these events and thereby influence future air quality in the region. Thus, the forecasts are of value only to the extent that they provide a basis for decision making. It may be argued that the uncertainties, assumptions, and poorly known quantities imbedded in the system severely hamper its potential for providing accurate forecasts. Yet, for providing useful information on the broad range of questions to be faced in the AQMP effort, no alternative approach will suffice. This latter view is, in a sense, the first technical assumption of the AQMP.

OVERVIEW OF THE FORECASTING SYSTEM

The forecasting system consists of three primary components: The ABAG Series III population, housing, employment, and land use modeling system; the MTC travel demand modeling system; and the BAAPCD's LIRAQ and Larsen air quality models. The interface between the air quality models and the ABAG/MTC models requires a series of data conversions which shall be collectively referred to as an emissions model. In addition, a separate effort to update the regional airport system plan will be coordinated with the AQMP to provide forecasts of aircraft activity. The arrangement of these component systems is shown schematically in Figure 1. In recognition of the interrelationship between population, housing, employment, land use, and transportation variables, the Series III projections and the travel demand models

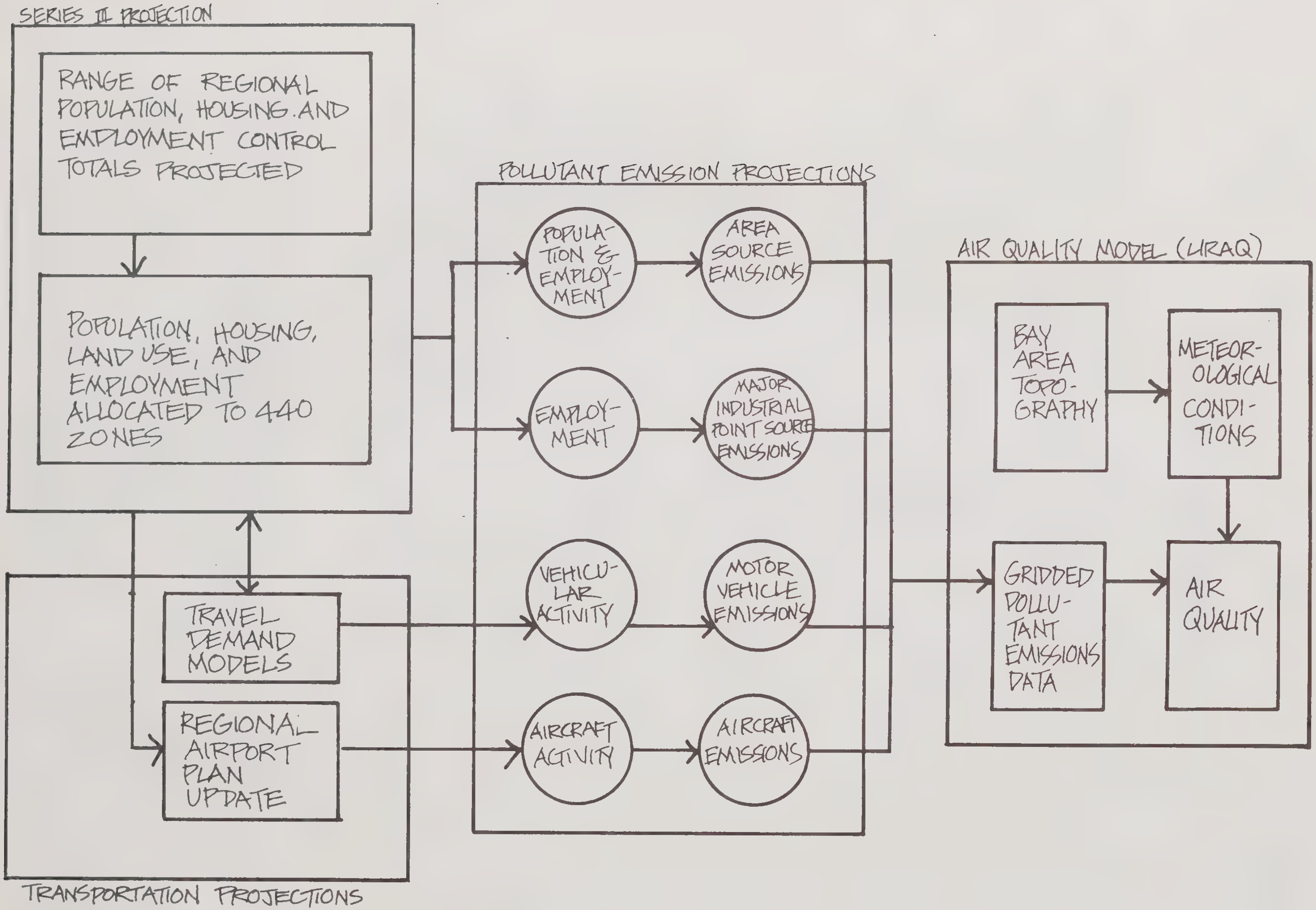


FIGURE 1

LONG RANGE AIR QUALITY PROJECTION/FORECASTING SYSTEM

share common data. The outputs of these two modeling systems together with the airport plan update provide the forecasts of human activity within the region which must then be translated into air quality terms for input to the air quality models.

Each of the components of the forecasting system will now be described in some detail. Where possible, key technical assumptions will be identified and discussed. In particular, Appendix A contains a more detailed technical description of the emissions forecasting assumptions and procedures. More detailed technical descriptions of both the Series III and travel demand assumptions and procedures are being prepared for the ABAG/MTC Projections Technical Advisory Committee (PTAC).

Since many of the linkages within the overall system represent novel applications of the various component modeling systems, many assumptions will of necessity evolve as we proceed with the analysis. Such assumptions are difficult to anticipate at the present stage of the AQMP effort, and thus cannot be discussed here. Subsequent memoranda will be developed as the need arises.

Following the descriptions of the system components, a series of examples of how various alternative control tactics can be tested within the system will be discussed.

This section will then be followed by a summary of time and resource constraints involved with exercising the system in the context of the Air Quality Maintenance Plan.

THE ABAG SERIES III PROJECTION SYSTEM

The ABAG Series III projections are a set of population, housing, employment, and land use forecasts for the nine county San Francisco Bay region. The projections are made from 1970 to the year 2000 in five-year intervals: 1975, 1980, 1985, 1990, 1995, and 2000. Additionally, they are spatially allocated to a system of 440 zones which cover the region. Each zone is composed of one or more census tracts, and the entire zonal system is illustrated in Figure 2.

The projection system is comprised of four models, two of which operate at an aggregated regional level, and two at the 440-zone level. The models include:

1. Regional Models
    - o Regional Demographic Model (APPLE)
    - o Regional Econometric Model
2. 440 Zone Level Models
    - o Basic Employment Models (BEMOD)
    - o Projective Land Use Models (PLUM)

Figure 2


SEE INSET
440 ZONES
BASED ON 1970 CENSUS TRACTS
1:1,000,000
1 in = approx. 16 miles

Figure 3 shows the four models and their interrelationships. The major assumptions and which models they control are also shown. Table 1 presents more detail on each of the models, their inputs and outputs, the respective assumptions, and their relationship to the other models.

At the regional level, the demographic model is controlled primarily by the assumptions regarding fertility, mortality, and migration. The econometric model is controlled by assumptions regarding national industrial growth and the regional industrial structure. National industrial projections will be taken from other agencies or institutions and not projected by ABAG. What we expect to occur in various industrial sectors, however, will be important assumptions that we must deal with.

The interconnection shown between these two models represents what is called the reconciliation process--that is, the demographic projections of labor force and the econometric projections of jobs must be consistent. The major balancing mechanisms contemplated at this time include migration and the regional industrial structure. For example, net migration will be increased or decreased depending on the respective projections. Unemployment will be trended from a current level to a long term unemployment level. Unemployment will be held relatively constant during the reconciliation process.

Details of the projection outputs for the regional models are shown in Table 1. These include population and household characteristics by age and sex, basic employment by 14 industrial classifications, and local-serving employment by 4 classifications. These outputs become control totals for the BEMOD and PLUM models.

The basic employment model (BEMOD) takes the basic employment control totals and allocates them to the 440 zones. An intermediate step is to disaggregate the regional employment totals to SMSA's (Standard Metropolitan Statistical Areas) to account for different industrial groups that are more prevalent in one SMSA or another.

In addition, BEMOD uses information from the local policy survey regarding land available for industrial development and highway and transit travel times supplied from the Metropolitan Transportation Commission (MTC).

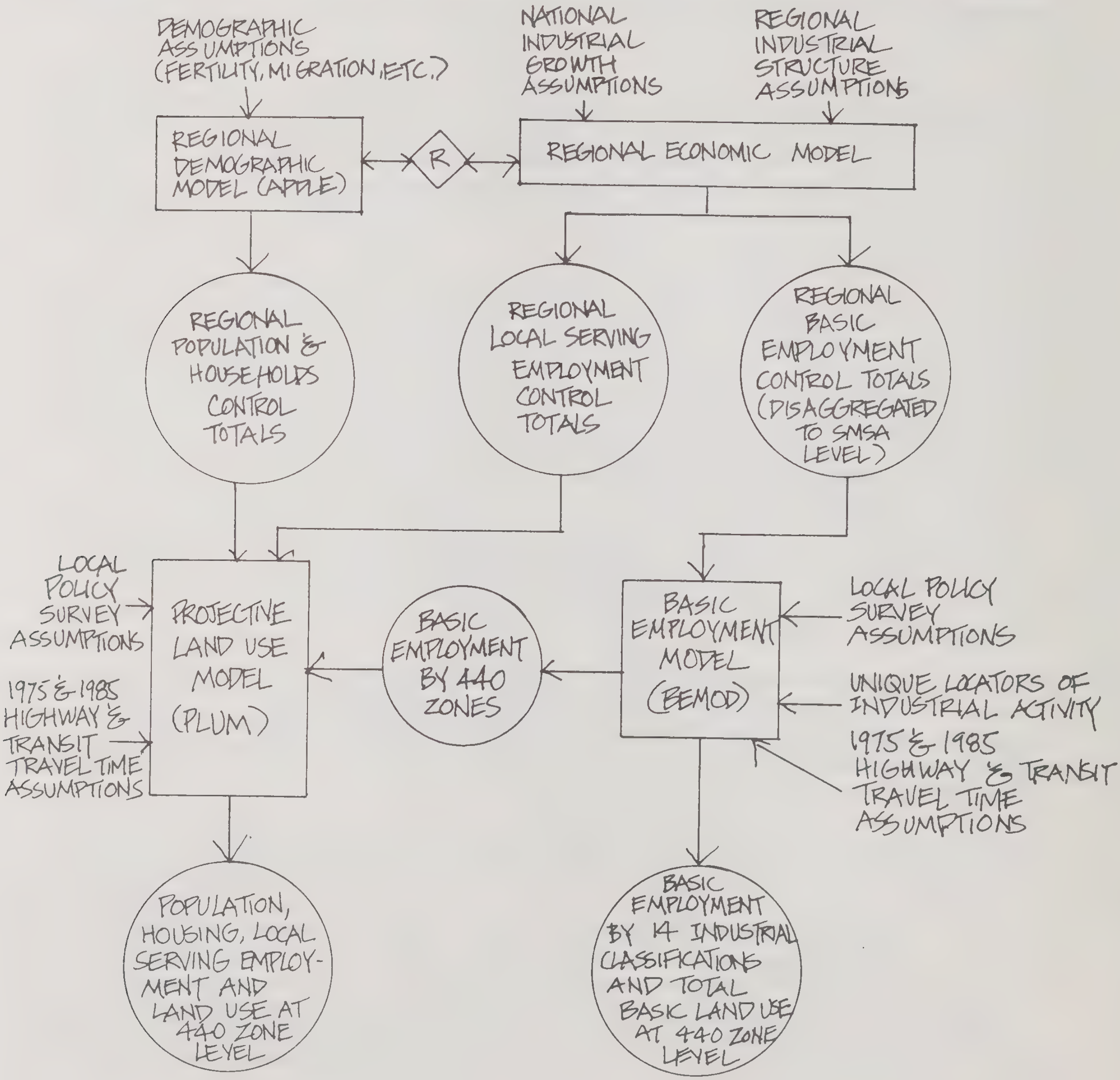
Actions that are occurring regarding the increase or decrease of specific activities of significant size--such as the closing of a large military installation or the construction or moving of a major plant--must be accounted for. These inputs to BEMOD are referred to as unique locators, so named because they can be uniquely specified. These are important inputs to BEMOD and influence the later projection of housing- and population-serving activities.

The basic employment by 14 industrial classifications and the total acreage developed is then provided as a projection output at the 440-zone level These outputs are also supplied to PLUM as inputs.

The projective land use model (PLUM) then takes the basic employment inputs, along with the regional control totals of population, households, and local-serving employment, and generates projections of population, housing units (by single and multi-family categories), and local-serving employment at the 440-zone levels.

FIGURE 3

SERIES III PROJECTION SYSTEM



INPUTS AND OUTPUTS OF THE MODELS
THAT COMPRISE THE SERIES III
PROJECTION SYSTEM

Model (Name)	Purpose	Method	Inputs: Data	Inputs: Assumptions	Important Assumptions	Outputs	Smallest Areal Unit of Projection	Projection Time Interval & Range	Relationship To Other Models
(1) Regional Demographic Model (APPLE)	To project regional population, households, & labor force	Cohort-Survival	1970 Civilian Pop. & Households/ 1970 Military Pop.	Fertility Timing of Fertility Mortality Migration Household Headship/Size Labor Force Participation Military Pop. Group Quarters School Participation	X (Fertility) X (Migration)	Population By Age & Sex Household Headship By Age Labor Force By Age & Sex School Enrollment By Age & Sex Group Quarter Pop. By Age & Sex	Regional (9 Bay Area Counties)	5 year intervals from 1970 to 2000	Provides population & labor force projections to econometric model. (These projections must be consistent with employment projections from econometric model. Consistency is primarily achieved through the adjustment of migration assumptions.) Also, the regional projections of population and households provide control totals for the PLUM model.
(2) Regional Econometric Model	To project regional employment	Statistical (Regression)		National Industrial Growth Regional Industry Structure	X (Regional Industry Structure)		Regional	1 year intervals from 1970 to 2000	Provides employment projections which are made consistent with the demographic model, as described above. Also, provides basic employment control totals for the BEMOD model. Also, provides local serving employment control totals for PLUM
(3) Basic Employment Model (BEMOD)	To allocate basic employment to the 440 Zones that subdivide the region	Statistical (Regression)	1970 Basic Employment by 440 Zones 1970 Developed Basic Acreage	Development Potential of Available Land For Basic Industry (From Local Policy Survey) Development Potential of Developed Land For Basic Industry Second Growth (From Local Policy Survey) Unique Locators (The probable location of major industrial development)	X (Development Potential of Available Land) X (Unique Locators)	Basic Employment By 14 Industrial Categories Total Basic Acreage Developed Total Available Industrial Acreage Remaining	440 Zones (each zone comprises one or more census tracts)	5 year intervals from 1970 to 2000	BEMOD receives basic employment control totals from the regional econometric model. These control totals are first disaggregated to the SMSA level and then BEMOD allocates basic employment within each of the four SMSA's. (The disaggregation from the regional to the SMSA level is accompolished through a modified Shift-Shares approach.) Also, BEMOD provides basic employment & acreages to the PLUM model. Also, highway & transit travel times are provided from travel analysis (from MTC).
(4) Projective Land Use Model (PLUM)	To allocate population, housing units, local serving employment & associated land uses to 440 Zones	Statistical (Probabalistic)	1970 Pop., Housing & Land Uses 1965 Hwy. & Transit Travel Times	Development Potential of Land Available For Residential Uses & Local Serving Employment (From Local Policy Survey) Development Potential of Land Available for 2nd Growth 1975 & 1985 Estimated Hwy. & Transit Travel Times	X (Development Potential of Land Available For Residential Uses)	Population & Housing By SF and MF Acreage Developed Development Potential of Available Acreage Remaining	440 Zones	5 year intervals from 1970 to 2000	PLUM receives basic employment by 440 Zone from BEMOD. Also, highway & transit travel times are provided from travel analysis (from MTC). PLUM receives regional population & household control totals from APPLE. Regional local serving employment control totals come from econometric models.

The major controlling assumptions for PLUM include the local policy survey assumptions regarding land available for development and transportation accessibilities as represented by the MTC highway and transit assumptions.

The local policy survey classifies those lands available or not available (e.g., public lands) for development. Lands available for development are further classified as having high, medium, and low development potential. Additional information is also supplied including expected density of development and whether second growth, such as redevelopment or infilling, is likely to occur.

THE MTC TRAVEL DEMAND FORECASTING SYSTEM

The MTC Travel Demand Forecasting System consists of two packages, the Demand Models and the Network Assignment Models. The demand forecasting process is a composite of 21 individual models, which are both multi-trip purpose and multi-modal in their scope. They are structured to be responsive to analyses of land use and transportation alternatives, and a wide variety of questions and policies of concern to MTC's regional transportation planning program.

Conventional Travel Demand Forecasting Systems

The standard system used nationwide for forecasting regional travel patterns and highway and transit needs consists of a series of models as follows:

- Trip generation model
- Trip distribution model
- Modal split model
- Network assignment model

Each of these types of models will be described, followed by a discussion of the technical advancements contained in the MTC system.

Trip Generation Model - Trip generation is the process of relating the number of trip origins and destinations to characteristics of the population and land use. Land uses such as single-family residential are considered origins for home-based trips. Similarly, commercial and industrial land uses typically are destinations for work trips. Based on the population, housing, employment, income, and land use characteristics of the various zones or communities within the region, the trip generation model specifies the number of daily trips beginning and ending in each zone throughout the nine-county Bay region.

Trip Distribution Model - Trip distribution is the process by which trips originating in each zone are distributed to the 440-zones in the region (including the zone of origin).

Of the several types of trip distribution models which have been built, the most widely used is the "gravity" model. This model loosely parallels Newton's gravitational law; it is based upon the assumption that all trips starting from a zone are attracted by the various "trip generators" in other zones, and this attraction is in direct proportion to the size of the

generator and in inverse proportion to the spatial separations between them. The spatial separation is measured in terms of the zone-to-zone travel time, which is in turn dependent upon the nature of the highway and transit facilities/services specified.

Modal Split Model - The proportion of total daily trips that would be made as auto driver, auto passenger, and transit rider are determined by the modal split model. This model incorporates the behavioral characteristics of the trip makers in terms of their responses to time and monetary costs associated with each trip. These costs are estimated for each alternative mode depending upon the highway and transit facilities/services specified.

Network Assignment Model - Network assignment is the process of routing trips to specific links (e.g., highway segments or transit routes) in the transportation system. Once the overall lines of travel and modes are determined, this model allocates the trips to the pre-specified highway and transit networks to determine traffic volumes and transit ridership in specific areas.

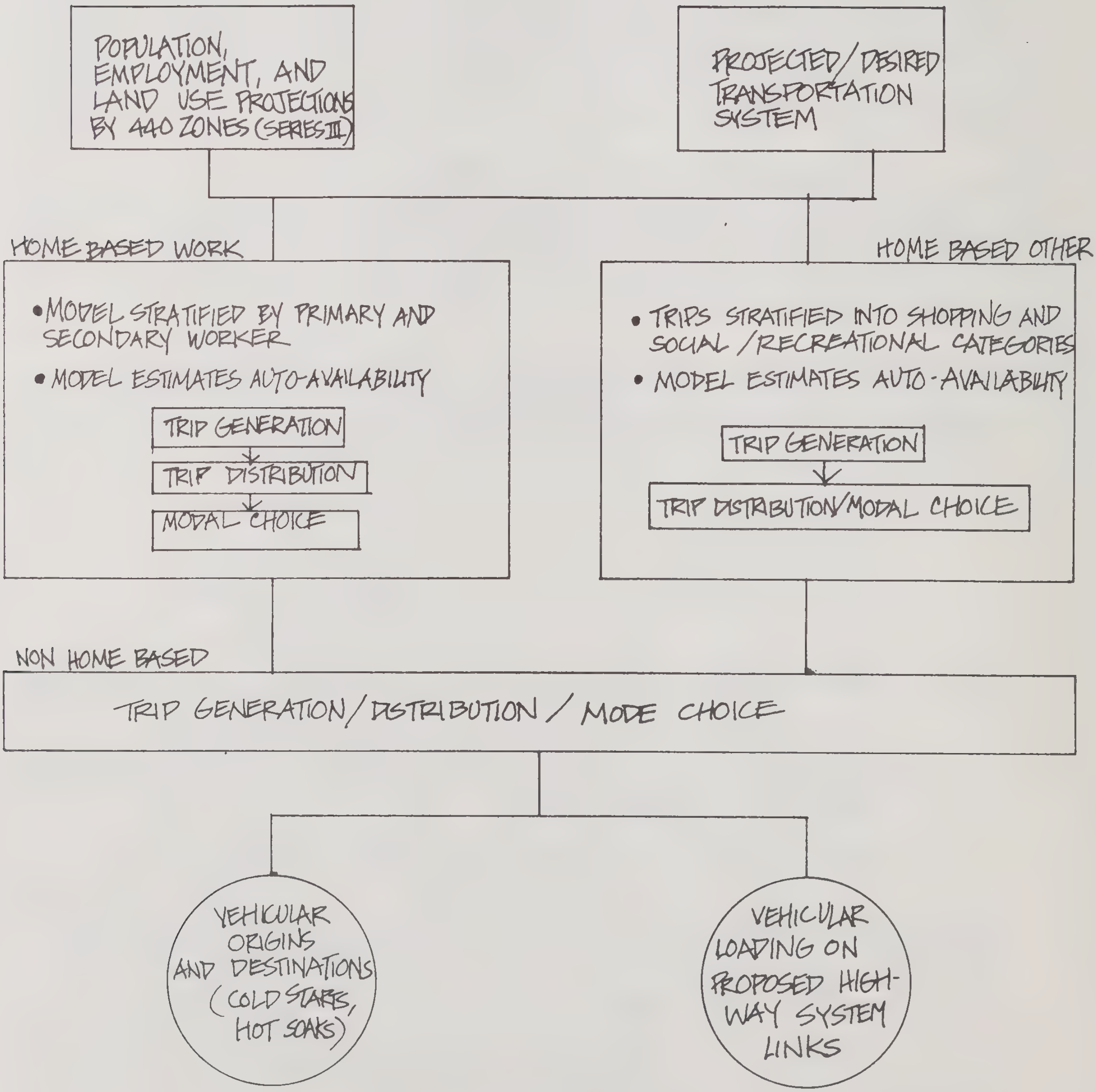
The MTC Travel Demand Forecasting System - The MTC forecasting system is illustrated schematically in Figure 4. It is similar to, but technically advanced beyond the conventional generation-distribution-mode split methodology. Among the major innovations present within the forecasting system are the following:

- o separate modeling of primary and secondary worker home-based work trip-making behavior
- o separate modeling of auto ownership behavior of households with workers and households without workers
- o income stratification of primary worker home-based work trip generation, distribution, and auto ownership
- o auto ownership stratification of secondary worker home-based work trip generation and distribution, home-based work mode split; and home-based non-work generation, distribution and mode split.
- o separate modeling of drive alone and share ride auto modes for home-based work trips.

The Network Assignment Package consists entirely of standard programs developed and maintained by the U.S. Department of Transportation: ULOAD (transit), LOADVN (highway), and CAPRES (highway capacity restraint), all on the UTPS/FHWA program battery.

Each of the component models of the forecasting system is disaggregate in nature, that is, based on household level samples, except the home-based work attraction model which is based on aggregate zonal data. All the models are estimated using 1965 Home Interview Survey data, except the work mode split model, which is estimated from 1972-73 data developed by UC's Travel Demand Forecasting Project (a research effort funded by the National Science Foundation).

FIGURE 4
MTC TRAVEL DEMAND FORECASTING SYSTEM



The model system forecasts travel demand for four trip purposes: home-based work, home-based shop, home-based social/recreation, and non-home based travel. In application (at an aggregate level) many of the model system components are further stratified by income group (low, medium, and high) and auto ownership troup (0, 1, and 2 or more). Work trip models are also stratified by primary worker (head of household) and secondary worker (other employed persons). The model system forecasts all travel on a 24 hour weekday basis, with the exception of highway capacity restraint, which utilizes a total vehicle trip matrix factored to a peak hour.

There are three main groups of variables that are input to the modeling system: socio-economic data, level-of-service data, and transportation network data. The socio-economic data base is obtained from the ABAG Series III projections. Included are employment, acreage, population, housing, resident workers, and income data.

The zonal level-of-service data depend largely on zone size and zone type (CBD, fringe, or other). Included as variables are peak and offpeak access, park, and walk terminal times for both attraction and production zones, peak and offpeak parking charges, and offpeak auto access distances for both attraction and production zones.

The transportation network data are derived from MTC's computer simulations of auto and transit networks. The variables included are:

- auto travel (peak and offpeak)
  - distance
  - travel time
  - tolls
- transit travel (peak)
  - fares
  - auto access time
  - first wait time
  - in-vehicle time
  - walk time
  - transfer time
- transit travel (offpeak)
  - fares
  - transit access and in-vehicle time
  - walk and wait time

The modeling system also requires some additional data items. These include separate estimates of the automobile operating cost, per capita living cost, mean parking duration by trip purpose, a shared ride pickup penalty time, and an average annual auto ownership cost.

The primary product of the model system is a set of 24-hour person trip matrices and network assignments:

1) drive alone home-based work trips
2) shared ride home-based work trips
3) transit home-based work trips
4) auto home-based shop trips
5) transit home-based shop trips
6) auto home-based social/recreational trips
7) transit home-based social/recreational trips
8) auto non-home-based trips
9) transit non-home-based trips
10) 24-hour weekday transit network assignments
11) 24-hour weekday vehicle network assignments
12) peak-hour weekday vehicle network assignments

1985 Highway and Transit System Assumptions

The following are the major new facilities or service assumed by MTC for the 1985 highway and transit systems:

- Highway - New interchange between I-580 and route 238
  - Partial extension of route 24 freeway in downtown Oakland
  - Napa River bridge in San Francisco
  - Extension of I-280 to Bay Bridge in San Francisco
  - I-280 and I-680 full interchange in San Jose
  - Partial Guadalupe Freeway in San Jose
- Transit - BART shuttle to the Oakland Airport
  - Richmond-Daly City BART line in operation
  - Expanded Santa Clara Co. transit district service, including I-680 express bus from San Jose to the Fremont BART station
  - Upgraded Southern Pacific service on the peninsula
  - Expanded San Mateo Co. transit district service
  - Exclusive bus lanes on Highway 101 and I-280 in San Mateo Co. and San Francisco

- MUNI Metro in the Market Street subway
- Larkspur Ferry Terminal in operation
- Expanded local bus service in eastern Contra Costa Co., Southern Alameda Co., and the North counties

EMISSIONS MODELING FOR AIR QUALITY ASSESSMENT

The broad range of air pollutant emissions sources may, for forecasting purposes, be conveniently grouped into four major categories:

- stationary point sources
- stationary area sources
- motor vehicles
- aircraft

Stationary Source Emissions

Stationary sources are divided into point and area source categories as a means of reducing the effort required to account for all of the individual sources. Those sources which emit a relatively large amount of pollutants are accounted for individually and are referred to as major point sources. Emissions from the more numerous smaller emitters are estimated in a collective fashion for an entire source type, such as domestic space heaters.

The basic procedure for projecting future emissions is the same for both stationary point and area source categories, and is shown in Figure 5. The growth or decline of activity for a given source category is assumed to be related proportionally to changes in one or more of the variables in the Series III forecast. For example, chemical processing emissions are assumed proportional to employment in the chemical processing industry, while domestic fuel combustion emissions are assumed proportional to population. In addition to the basic assumption of proportionality, changes in the emission rate per unit of activity for a given source category may be superimposed to account for improvements in control technology or changes in the type of fuel used. The current status of control for the various stationary source categories will be reviewed in a separate memorandum, and will not be repeated here.

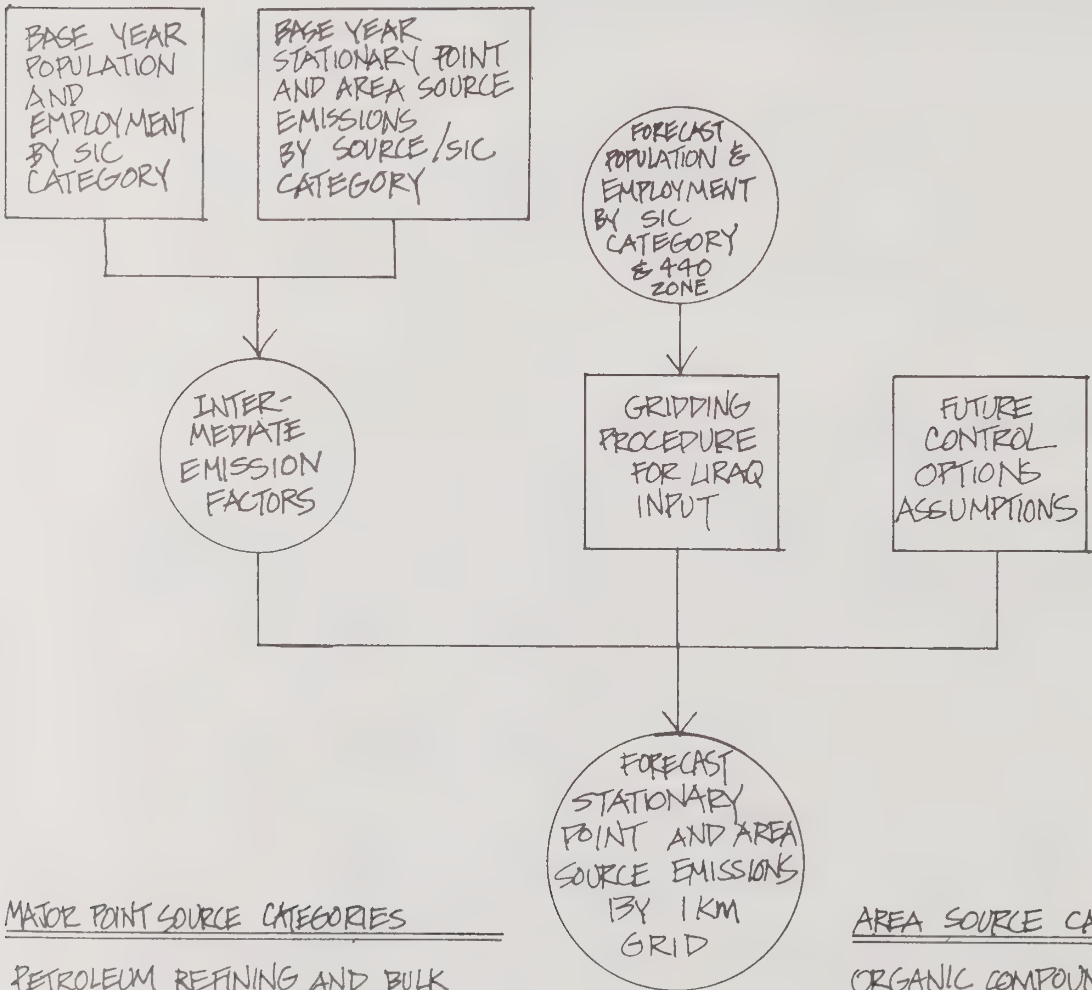
Motor Vehicle Emissions

The procedure for projecting motor vehicle emissions is shown in Figure 6. Vehicular activity data which is output from the MTC travel demand modeling system must be divided into five basic categories:

- motorcycle travel by link
- auto trip-making activity by 440 zone
- auto travel by link
- gasoline truck travel by link
- diesel truck travel by link

FIGURE 5

STATIONARY POINT AND AREA SOURCE EMISSIONS FORECASTING PROCEDURE



MAJOR POINT SOURCE CATEGORIES

PETROLEUM REFINING AND BULK HANDLING

CHEMICAL PROCESSING

OTHER INDUSTRIAL/COMMERCIAL

ORGANIC COMPOUNDS STORAGE TANKS

POWER PLANTS

AREA SOURCE CATEGORIES

ORGANIC COMPOUNDS EVAPORATION

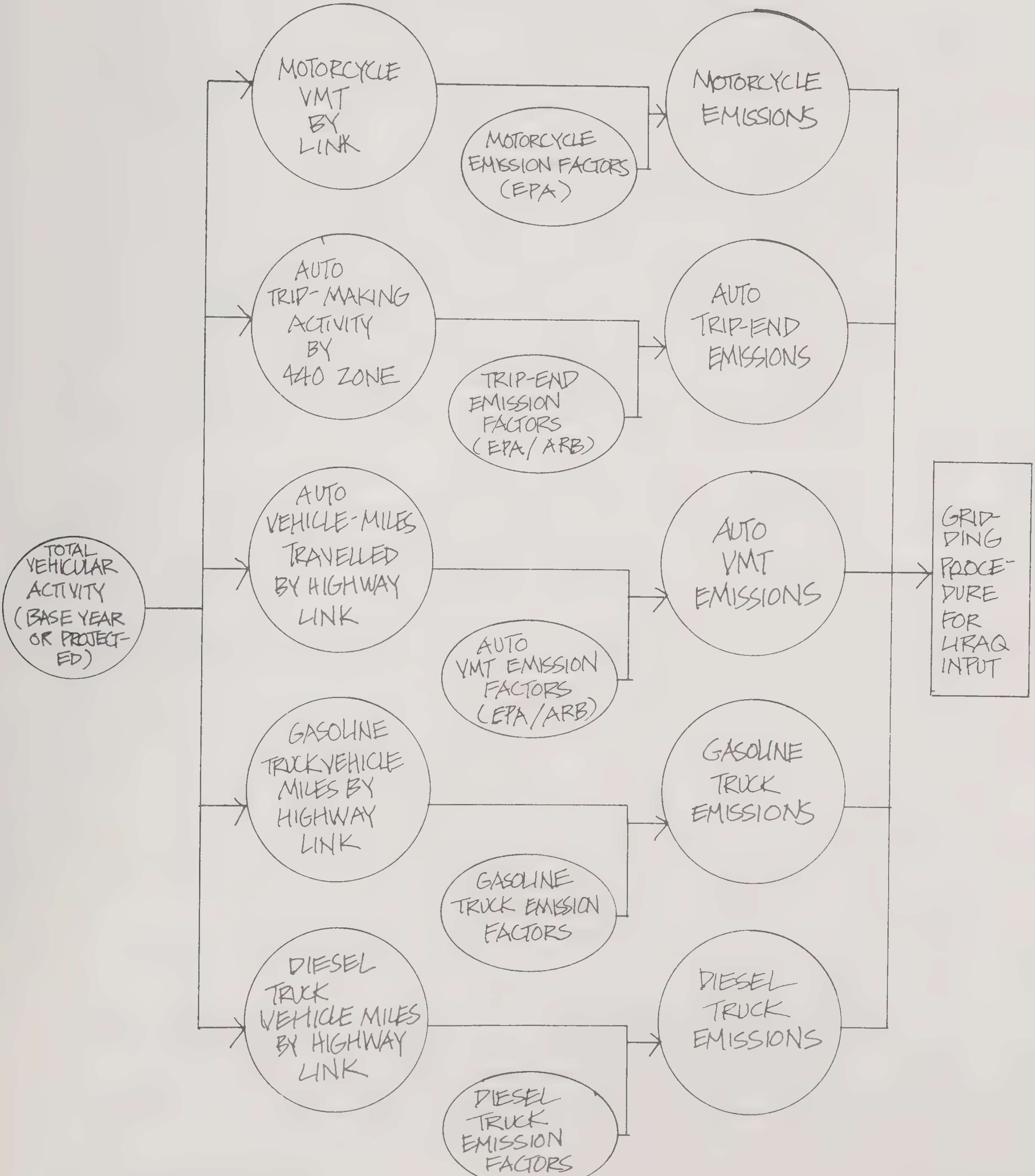
GASOLINE MARKETING (SERVICE STATIONS)

DOMESTIC, COMMERCIAL, & INSTITUTIONAL FUEL COMBUSTION

BURNING OF MATERIALS

OFF-HIGHWAY MOBILE SOURCES (TRACTORS, CONSTRUCTION EQUIPMENT, SHIPS, RAILROADS, ETC)

FIGURE 6
MOTOR VEHICLE EMISSIONS FORECASTING PROCEDURE



This division is required because each of the vehicle types has different sets of emissions, vehicle population, and age distribution data. Generally, the divisions will be estimated as percentages of total vehicular travel on the links of the highway network. In the particular case of automobiles, an additional category of trip-related emissions has been included so that separate accounting of trip-end related emissions may be made. Specifically, these trip-end emissions may be described as follows:

- The "cold start" - When an engine is operated in a cold condition, the carburetor does not effectively vaporize the gasoline before injection into the combustion cylinders, and, in addition, the phenomenon of "quenching" of the combustion flame at the cylinder wall is enhanced. These factors lead to increased exhaust hydrocarbon emissions for all automobiles when the engine is cold. For late-model autos equipped with catalysts, cold start emissions are made more significant because the catalyst functions most efficiently only at very high termperatures. Thus, when the engine is warm the catalyst removes pollutants as it was designed to do; when it is cold, the catalyst is relatively ineffective.

- The "hot soak" - At the end of a trip, when the engine is turned off, the gasoline remaining in and around the carburetor which would have been combusted had the engine continued running is instead vaporized due to the heat produced by the engine and escapes to the atmosphere.

As more and more catalyst-equipped vehicles are introduced into the Bay Area's vehicle population, the actual vehicle miles travelled will decline in significance, while trip-making activity will become the significant measure of pollution production by autos.

The latest emission standards for motor vehicles now in effect are summarized in Table 2. As shown in the table, the California Air Resources Board has approved a more stringent schedule for reducing emissions from new motor vehicles than the Federal Environmental Protection Agency. Emission factors used in the motor vehicle emissions projections will assume that these standards are met by the vehicle manufacturers*. These factors as well as the emission factors for the other motor vehicle categories listed (gasoline trucks, diesel trucks, and motorcycles) will be obtained from the standard U.S. EPA document, "Compilation of Air Pollutant Emission Factors." (Specifically, Supplement 5 to AP-42 or later version if available and modified for California.)

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*Considering past delays in the Federal Motor Vehicle Control Program, as well as the current uncertainty regarding the Clean Air Act, the assumption that future emission standards will be met is quite significant. If met, the role of the automobile in air pollution will be greatly diminished, and the resulting AQMP will likely reflect this situation with fewer auto-related control programs.

TABLE 2

NEW VEHICLE STANDARDS SUMMARY

Increasingly stringent emission standards for new vehicles have been imposed by State and Federal law. The summary of regulations is printed below:

Passenger Cars, Light Duty Trucks, and Medium Duty Vehicles

YEAR		STANDARD	COLD START TEST	HYDROCARBONS	CARBON MONOXIDE	OXIDES OF NITROGEN
Prior to controls			7-mode	850 ppm	3.4%	1000 ppm
			7-mode	(11 gm/mi)	(80 gm/mi)	(4 gm/mi)
			CVS-75	8.8 gm/mi	87.0 gm/mi	3.6 gm/mi
1966-1967	PC & LDT	Calif.	7-mode	275 ppm	1.5%	no std.
1968-1969	PC & LDT	Calif. or Federal	7-mode			
			50-100 CID	410 ppm	2.3%	no std.
			101-140 CID	350 ppm	2.0%	no std.
			over-140 CID	275 ppm	1.5%	no std.
1970	PC & LDT	Calif. & Federal	7-mode	2.2 gm/mi	23 gm/mi	no std.
1971	PC & LDT	Calif.	7-mode	2.2 gm/mi	23 gm/mi	4 gm/mi
		Federal	7-mode	2.2 gm/mi	23 gm/mi	—
1972	PC & LDT	Calif.	7-mode or	1.5 gm/mi	23 gm/mi	3 gm/mi
			CVS-72	3.2 gm/mi	39 gm/mi	*3.2 gm/mi
		Federal	CVS-72	3.4 gm/mi	39 gm/mi	—
1973	PC & LDT	Calif.	CVS-72	3.2 gm/mi	39 gm/mi	3 gm/mi
		Federal	CVS-72	3.4 gm/mi	39 gm/mi	3 gm/mi
1974	PC & LDT	Calif.	CVS-72	3.2 gm/mi	39 gm/mi	2 gm/mi
		Federal	CVS-72	3.4 gm/mi	39 gm/mi	3 gm/mi
1975	PC	Calif.	CVS-75	0.9 gm/mi	9.0 gm/mi	2.0 gm/mi
	PC.	Federal	CVS-75	1.5 gm/mi	15 gm/mi	3.1 gm/mi
	LDT	Calif.	CVS-75	2.0 gm/mi	20 gm/mi	2.0 gm/mi
	LDT	Federal	CVS-75	2.0 gm/mi	20 gm/mi	3.1 gm/mi
1976	PC	Calif.	CVS-75	0.9 gm/mi	9.0 gm/mi	2.0 gm/mi
	PC	Federal	CVS-75	1.5 gm/mi	15 gm/mi	3.1 gm/mi
	LDT	Calif.	CVS-75	0.9 gm/mi	17 gm/mi	2.0 gm/mi
	LDT	Federal	CVS-75	2.0 gm/mi	20 gm/mi	3.1 gm/mi
1977	PC	Calif.	CVS-75	0.41 gm/mi	9.0 gm/mi	1.5 gm/mi
	PC	Federal	CVS-75	1.5 gm/mi	15 gm/mi	2.0 gm/mi
1977-78	LDT	Calif.	CVS-75	0.9 gm/mi	17 gm/mi	2.0 gm/mi
	LDT	Federal	CVS-75	NOT	ESTABLISHED	
1978	PC	Calif.	CVS-75	0.41 gm/mi	9.0 gm/mi	1.5 gm/mi
	PC	Federal	CVS-75	NOT	ESTABLISHED	
	MDV	Calif.	CVS-75	0.9 gm/mi	17 gm/mi	2.3 gm/mi

The values in parentheses are approximately equivalent values by 7-mode test.

PC — Passenger Cars

LDT — Light Duty Trucks (under 6001 lbs. GVW)

MDV — Medium Duty Vehicles (6001-8500 lbs. GVW)

ppm — parts per million concentration

gm/mi — grams per mile

7-mode — is a 137 second driving cycle test.

CVS-72 — is a Constant Volume Sample cold start test.

CVS-75 — is a Constant Volume Sample test which includes cold and hot starts.

* — hot 7-mode

TABLE 2, CONTINUED

Heavy-duty Vehicles Over 6,000 lbs.**

YEAR	STANDARD		HYDROCARBONS	CARBON MONOXIDE	OXIDES OF NITROGEN	HYDROCARBONS PLUS OXIDES OF NITROGEN
*1969-1971	State-gasoline		275 ppm	1.5%	no std.	
1972	State-gasoline		180 ppm	1.0%	no std.	
1973-1974	State-gasoline & diesel			40 gm/BHP hr.		16 gm/BHP hr.
1975-1976	State-gasoline & diesel			30 gm/BHP hr.		10 gm/BHP hr.
**1977-1978	State-gasoline & diesel	either		25 gm/BHP hr.		5 gm/BHP hr.
		or	1.0 gm/BHP hr.	25 gm/BHP hr.	7.5 gm/BHP hr.	
1979	State-gasoline & diesel	either	***1.5 gm/BHP hr.	25 gm/BHP hr.	7.5 gm/BHP hr.	
		or		25 gm/BHP hr.		5 gm/BHP hr.
1980-1982	State-gasoline & diesel	either	1.0 gm/BHP hr.	25 gm/BHP hr.		6.0 gm/BHP hr.
		or		25 gm/BHP hr.		5.0 gm/BHP hr.
1983 and sebsequent	State-gasoline & diesel		0.5 gm/BHP hr.	25 gm/BHP hr.		4.5 gm/BHP hr.

gm/BHP hr. - grams per brake horsepower-hour

*Federal standards remained at this level through 1973. The Federal Government adopted standards for heavy-duty gasoline and diesel vehicles for 1974 and subsequent model years which are identical to California's 1973-74 standards.

**Except Medium Duty Vehicles in 1978 and later. (see New Vehicle Standards Summary on opposite page)

***Use of the flame ionization detector in the 1979 and later tests will result in higher hydrocarbon readings than the non-dispersive infra-red instrumentation currently in use.

State Smoke Standards for Heavy-Duty Vehicles

1971 and later vehicles may discharge smoke no darker than Ringelman 1 or 20 percent opacity for up to 10 seconds.

Vehicles sold before 1971 may discharge smoke not darker than Ringelman 2 or 40 percent opacity for up to 10 seconds.

Crankcase Emissions

On all new vehicles manufactured for sale in California after January 1, 1964, crankcase emissions are virtually zero. Comparable Federal standards became effective in 1968 for light-duty vehicles, and 1970 for heavy-duty vehicles.

Evaporative Emissions

Evaporative emissions of hydrocarbons have been 6 gms/test for light-duty vehicles since 1970 and 2 gms/test since 1972 by the carbon trap approval test procedure. The evaporative emission requirements for 1978 light-duty vehicles will be 6 gms/test by the SHED (Sealed Housing for Evaporative Determinations) test procedure. Since 1973, heavy-duty gasoline-powered vehicles have been required to meet the same standards as light-duty vehicles by engineering evaluation.

Motorcycle Emissions Standards

New motorcycles manufactured for sale in California on or after January 1, 1978, will be required to meet a hydrocarbon (HC) exhaust emission limit of 10.0 grams per kilometer. The limit will be reduced to 5.0 gm/km on January 1, 1980, and 1.0 gm/km on January 1, 1982.

Aircraft Emissions

The procedure for forecasting emissions resulting from aircraft operations is illustrated in Figure 7. Data on aircraft activity at each airport in the region will be obtained from the MTC regional airport plan, which is currently being updated. Emission factors for aircraft operations will be obtained from EPA. In addition, EPA has recently promulgated a set of increasingly stringent emission regulations for various aircraft engine types. These regulations, which are summarized in Table 3, have been adopted for new aircraft engines beginning in 1979. Presuming that aircraft engines have roughly a 14 year life, it is anticipated that the full impact of these regulations will not be felt until about 1993. However, retrofit regulations have been proposed by EPA for inuse aircraft gas turbine engines of Class T2 and of rated power of 29,000 pounds of thrust or greater. If adopted, these regulations would require emission reductions from these inuse engines comparable to the 1979 standards already adopted for new Class T2 engines. The retrofit requirements would not become effective until January 1, 1983.

AIR QUALITY FORECASTING

The modeling system to be used for forecasting future air quality in the region consists of the Lawrence Livermore Laboratory LIRAQ models supplemented by the statistical Larsen model and various Guassian models for sub-regional and/or microscale analyses. These models have been described in AQMP/Issue Paper 1 (September 1976), and rather than repeating that description, this section will identify key issues related to the use of the modeling system. Final resolution of the issues will be proposed in a future AQMP Issue Paper.

There are three key issues regarding the use of the modeling system, as follows:

- Hydrocarbon reactivities
- Measuring air quality improvements
- Interpretation of a "worst-case" forecast

Hydrocarbon Reactivities

LIRAQ employs a hydrocarbon classification scheme which divides the emissions into three categories. These categories differ from the three-level reactivity classification scheme adopted by the California Air Resources Board. The LIRAQ classification is based on generalized photo chemical reaction characteristics of the various hydrocarbon types, while the ARB classification is based on smog chamber test data and reflect differing rates of oxidant production. The use of any hydrocarbon classification other than that approved by ARB must be accompanied by some form of documented justification.

Measuring Air Quality Improvements

LIRAQ will forecast air quality throughout the region, spatially averaged over 1, 2, or 5 kilometer squares. In contrast, the existing air quality monitoring network measures air quality at specific points scattered about

FIGURE 7

AIRCRAFT EMISSIONS FORECASTING PROCEDURE

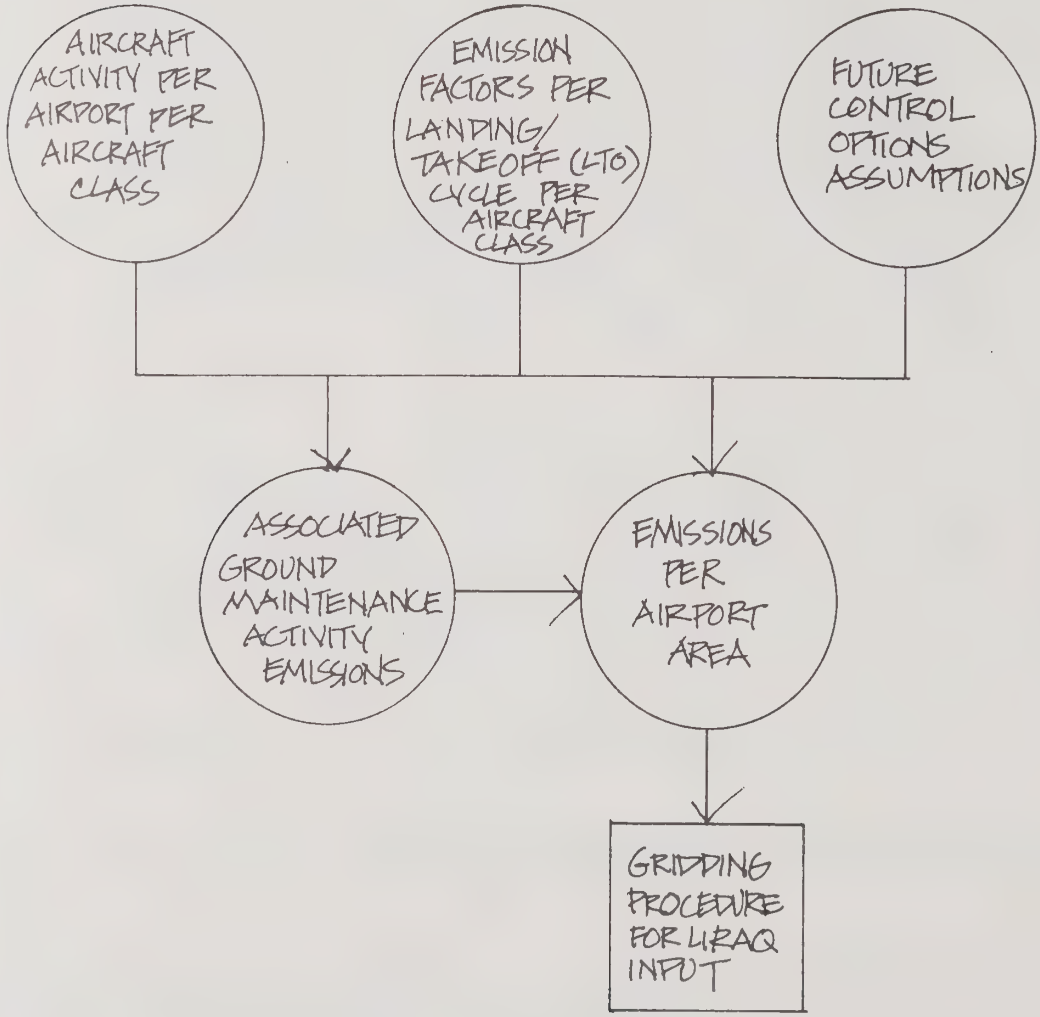


Table 3

Summary of Aircraft Emission Rates

Engine Type & Classification (Emission Units)	Pollutant	Existing Emission Rate[2]	Emission Standards (Date Applicable)	Percent Reduction
Business Jet-T1 (lbs/1000 lb-thrust hrs/cycle)	HC	28	1.6 (1/1/79)	94%
	CO	122	9.4 (1/1/79)	92%
	NO_x	12	3.7 (1/1/79)	69%
Jumbo Jet-T2 (lbs/1000 lb-thrust hrs/cycle)	HC	2.9	0.8 (1/1/79)	72%
	CO	11.2	4.3 (1/1/79)	62%
	NO_x	7.5	3.0 (1/1/79)	60%
	HC	2.9	0.4 (1/1/81)	86%
	CO	11.2	3.0 (1/1/81)	73%
Long-Range Jet T-3 (lbs/1000 lb-thrust hrs/cycle)	HC	24	0.8 (1/1/79)	97%
	CO	28	4.3 (1/1/79)	85%
	NO_x	5	3.0 (1/1/79)	40%
	HC	24	0.4 (1/1/81)	98%
	CO	28	3.0 (1/1/81)	89%
Medium-Range Jet T-4 (lbs/1000 lb-thrust hrs/cycle)	HC	4	0.8 (1/1/79)	80%
	CO	12	4.3 (1/1/79)	64%
	NO_x	7	3.0 (1/1/79)	57%
	HC	4	0.4 (1/1/81)	90%
	CO	12	3.0 (1/1/81)	75%
Supersonic Jets-T5 (lbs/1000 lb-thrust hrs/cycle)	HC		3.9 (1/1/80)	
	CO		30.1 (1/1/80)	
	NO_x		9.0 (1/1/80)	
	HC		1.0 (1/1/84)	
	CO		7.8 (1/1/84)	
	NO_x		5.0 (1/1/84)	
General Aviation Piston - P1 (lbs/ rated power/cycle)	HC	0.0018	0.0019 (1/1/80)	0%
	CO	0.075	0.042 (1/1/80)	44%
	NO_x	0.0003	0/0015 (1/1/80)	0%
General Aviation Turboprop - P2 (lbs/1000 hp-hrs/ cycle)	HC	14.5	4.9 (1/1/79)	66%
	CO	40.8	26.8 (1/1/79)	34%
	NO_x	15.8	12.9 (1/1/79)	18%

1) Rated power for engine classifications were obtained from Dick Munt of EPA Research Triangle Park, North Carolina (12/15/76)

2) Emission rates were calculated by converting AP-42 emission factors (Table 3.2-13) to EPA Parameters using methodology obtained from Dick Munt of EPA (12/15/76)

3) 40CFR87, "Environmental Protection Agency Regulations on Control of Air Pollution from Aircraft and Aircraft Engines", Environment Reporter, November 12, 1976, pp. 29-42.

the region. Thus, the comparison of forecast air quality with existing air quality is not straightforward. In the case of forecast air quality, there is only one source of information, namely, the forecast system. In the case of existing air quality there are two sources of information--the monitoring data and the outputs from the model validation analysis. If the forecast data is compared to the validation data for the same day, like quantities will be compared, and a consistent interpretation of air quality improvement can be made. However, since the model validation never entirely matches the monitored data, one cannot be confident that the air quality forecasted at specific locations is realistic in any absolute sense. On the other hand, comparison of forecast air quality with base year monitoring data leads to even greater difficulties in interpretation because the monitoring data may not be absolute or representative either. Occasional irregularities in instrument operation, as well as localized site conditions lead to this problem in interpreting monitoring data.

A second issue is related to the definition of air quality improvement. A variety of alternative definitions are possible, for example:

- Percent reduction in peak levels at monitoring station locations
- Percent reduction in daily averaged pollutant concentration levels at monitoring station locations
- Percent reduction in peak level for the region wherever it may occur
- Percent reduction in population-exposure using some form of exposure index

The problems are twofold: first, the interpretation of air quality in terms of existing standards and regulations is not necessarily the most meaningful interpretation for the public and local politicians who must accept the plan; and second, the use of a model capable of providing data over the entire region instead of at specific locations raises questions concerning the interpretation of peak concentrations.

Interpretation of a Worst-Case Forecast

Another issue related to the interpretation of LIRAQ forecasts is how those forecasts are to be related to air quality standards. The standards are defined in terms of concentrations which are either not be exceeded (state standards), or to be exceeded not more than once per year (federal standards). In either case, a forecast of worst case conditions would be required to provide an appropriate comparison with the air quality standards. Four days of meteorological data are currently available for LIRAQ use. None are "worst case days" according to historical monitoring records. This is especially true for carbon monoxide, sulfur dioxide, and suspended particulate matter.

There are at present two possible ways to resolve this problem. First, additional days of meteorological data could be prepared which would indeed be representative of worst case conditions. The problem with this approach is that the preparation of meteorological data sets for additional

days requires a substantial commitment of staff and monetary sources for both data preparation and additional model validation. (Roughly 10-20 person-weeks and $2,000-$5,000 computer time for each additional day.) A second approach would be to develop a statistical characterization of meteorological conditions for the Bay Area, determine where on the distribution the existing days lie, and then infer worst-case conditions using the statistical function developed. The Larsen characterization of air quality monitoring data is the most obvious example of this approach, although other alternatives could conceivably be developed. This latter approach lacks the methodological consistency of the first approach, but would be relatively simple to implement.

EVALUATION OF ALTERNATIVE CONTROL MEASURES

The primary value of the forecasting system is its capacity for testing a wide range of alternative control measures against a common baseline forecast. Thus, technological or hardware controls can be tested on a consistent footing with transportation and land use controls. This section briefly describes how the forecasting system can be used to test sample control measures in each category. It should be noted that the results of the tests are a measure of the effectiveness of such controls for improving air quality in the region. Individual components of the system can also be used to provide information about the effects of a control with respect to other assessment criteria (e.g., costs, mobility) which will not be discussed here.

Technological Controls

Technological controls can be tested with relative ease because they do not involve significant changes in human activities. Rather, they involve the implementation of improved techniques for reducing the pollutant emissions resulting from normal human activities. Such emission reductions may be accounted for by applying a percentage reduction factor to the "emission factors" indicated in Figures 5, 6, and 7. For example, requiring even more stringent control of motor vehicle emissions than currently required could be reflected in future motor vehicle emission factors. This would then serve as input to the emissions calculations which subsequently are input to the air quality models. Regulations for substituting non reactive solvent bases or for implementing combustion modifications for reducing NO_x emissions from small industrial and utility boilers can be handled similarly.

Transportation Controls

Transportation controls may be tested through the travel demand modeling system. Depending on the specific nature of the controls different approaches to simulating their effects may be taken. For example, the effect of a general regionwide improvement in transit service may be tested by changing the transit travel time or "wait time" in the modal split model. This will then produce an estimate of the percent of total trips diverted to transit as a result, and will produce a net decrease in the traffic on the highway network. Testing service improvements in specific areas will involve changing the transit network to reflect

the improvements, which is a more tedious and labor-intensive task. Cost incentives/disincentives such as gasoline tax or increased parking costs can be simulated in the modal split model.

Once the travel demand models have been run to test the alternative controls, the output is fed through the emissions calculations and ultimately to the air quality models.

Land Use Controls

The effectiveness of individual land use control mechanisms cannot be tested by the forecasting system in a straightforward manner. What can be tested are the ultimate objectives of land use control measures. For example, one objective of land use control for improving air quality may be to halt the outward spread of the metropolitan area boundaries and redirect future growth into existing urbanized portions of the region. The effectiveness of specific mechanisms or tools which are employed to accomplish this result (e.g., tax incentives/disincentives, public facility restrictions, changes in general plans and/or zoning ordinances) cannot be tested by the forecasting system. Instead, the system can be used to test the effect of accomplishing that objective on regional air quality. The land use objective in effect becomes an assumption for a subsequent reiteration of the Series III forecasts. The results of these forecasts are then fed through the modeling sequence to produce estimates of resulting air quality. The information thus obtained can be used to decide whether the assumed land use objectives are indeed viable goals to pursue with the range of implementation tools available.

Land use controls or objectives are the most difficult and time-consuming to forecast. This is due not only to the difficulties in developing clear statements of those objectives, but also the fact that changes in the Series III outputs will necessitate additional runs of the subsequent travel demand, emissions, and air quality models.

TIME AND MONETARY RESOURCE CONSTRAINTS

The size and complexity of the forecasting system is such that the time and monetary resources required to produce a single complete run of the entire sequence is substantial. Estimates of staff and computer costs for each major component of the system are shown in Table 4. A range is shown in each case since much depends upon the nature of the changes made to analyze a specific set of conditions. The basic conclusion to be drawn, however, is that the cases to be analyzed should be carefully selected before a complete sequence of runs is committed. In particular, extensive use of prescreening techniques should be made so that the control measures which are finally tested have the greatest potential for improving air quality. The types of prescreening techniques to be employed will be documented in a separate technical memorandum when the candidate controls are specified in greater detail. In general, working experience with existing programs as well as the wealth of previous studies performed on various aspects of proposed controls will provide the basis for the prescreening.

Table 4. Estimated Staff and Computer Costs for Major Components of the Forecasting System

Component	Typical Staff Resources Required to Prepare and Analyze a Run (person-weeks)	Computer Cost
Series III[a]	2-4	$ 800
Travel demand[b]	2-5	3,500
Emissions input	1	negligible
Air Quality (LIRAQ)[c]	2-4	2,100
Total	7-14 person-weeks	$ 6,400

(a) Assumes no changes in the demographic or econometric models. Only basic employment allocation and the projective land use model would likely be involved in control measure analysis.

(b) Assumes a complete sequence of model runs including trip generation, distribution, mode split, and network assignment. Specific measures may require less significant resource commitments.

(c) Assumes three runs each of LIRAQ-1 and LIRAQ-2 to adequately test each strategy under varying meteorological conditions.

Finally, it should be noted that the substantial staff resources required to produce the forecasts implies a strong need to minimize the number of times the forecasting system is executed. This is clear from both a resource standpoint as well as a scheduling standpoint. The number of cycles for execution of the complete system in testing control strategies will likely be restricted to:

- one or two land use control strategies
- two or three transportation control strategies
- two or three technological control strategies

Each strategy would consist of a group of individual control measures which have been demonstrated through the prescreening process to have a significant potential for improving air quality. The different strategy options would reflect varying levels of severity of the control measures in terms of their perceived impacts on the region (e.g., costs, mobility, political acceptability, etc.)

AQMP Tech Memo 2

PROJECTIONS/FORECASTING:
SYSTEM DESCRIPTION AND TECHNICAL ASSUMPTIONS

APPENDIX A

PROPOSED METHODOLOGY FOR 1975 AQMP SOURCE INVENTORY

Prepared by BAAPCD/R&P Staff for the

AQMP Joint Technical Staff

December 15, 1976

INTRODUCTION

Because it defines the sources of air pollution relatively and quantitatively, the emissions inventory is one of the more important inputs for air quality models. The inventory provides information concerning source emissions and defines the location, frequency, duration, and relative contribution of the emissions.[1] Therefore, success of any air quality model heavily depends on development of an accurate emissions inventory. The inventory must include all pollutant sources, both mobile and stationary. Emission rates must be specified for relatively short time intervals and moderately small geographical areas--typically one or two kilometers (or miles) square.

Since the Bay Area Air Quality Maintenance Planning (AQMP) study designated the Livermore Air Quality Model (LIRAQ) as a primary air quality simulation model for the study, the source inventory for AQMP would be focused upon the quality and resolution required by the LIRAQ model. LIRAQ has been designed to yield hourly average pollutant concentrations with spatial resolution of a kilometer or more. Therefore, the objective of the development of the source inventory for AQMP would be to provide emission rates on an hourly basis with a spatial resolution of 1 km for the pollutant of interest.

In conjunction with the 1973 LIRAQ study, the Bay Area Air Pollution Control District (BAAPCD) developed a comprehensive and detailed source inventory. Therefore, it is our intent to develop the AQMP source inventory by modifying the existing sources of data and procedures rather than generating new procedures and new data. In constructing the source inventory for AQMP, it is proposed to divide pollutant emissions into four source-categories as required by the LIRAQ model. They are: motor vehicles, aircraft, major point sources, and non-major sources. Table 1 presents the distribution by source-origin category of total daily Bay Area emissions of various pollutants for 1973. The table also indicates the magnitude of each source-category. Figure 1 illustrates steps involved in developing a source emission file for use by the LIRAQ model.

The purpose of this report is to describe the details of the four source categories and various procedures to be used to develop an appropriate source inventory for the AQMP study.

MAJOR POINT SOURCES

Data concerning emissions from 116 major industrial operations are maintained as part of the 1975 BAAPCD source inventory.[2] These data are prepared by the BAAPCD's Engineering Division using a variety of methods ranging from actual measurement of stack gases to estimates derived from fuel usage record.[3] Table 2 shows the 1975 estimates of the actual and percentage contributions of major point sources to the total Bay Area stationary source emissions of various pollutants of interest.

Table 1 - 1973 Distribution by source-orgin category of total daily Bay Area emissions of various pollutants for typical summer weekday.

Source-origin Category	Contribution to Greater Bay Area regional daily total (%)						
	Particulate	Alkanes	Alkenes	Aldehydes	Nitric oxide	Sulfur dioxide	Carbon monoxide
Mobile	18.6	33.3	30.5	100.0	59.7	3.8	85.9
Population-distributed	54.5	51.5	53.7	-	11.3	10.3	8.9
Airport	7.3	2.0	2.0	-	1.5	0.5	2.1
Major point sources:							
Ground-based	3.6	12.0	12.5	-	3.7	5.5	1.7
Elevated	16.1	1.1	1.1	-	23.8	80.0	1.3
	Total daily regional emissions (kg)						
	1.39×10^5	5.94×10^5	2.81×10^5	1.18×10^4	4.62×10^5	2.60×10^5	2.06×10^6

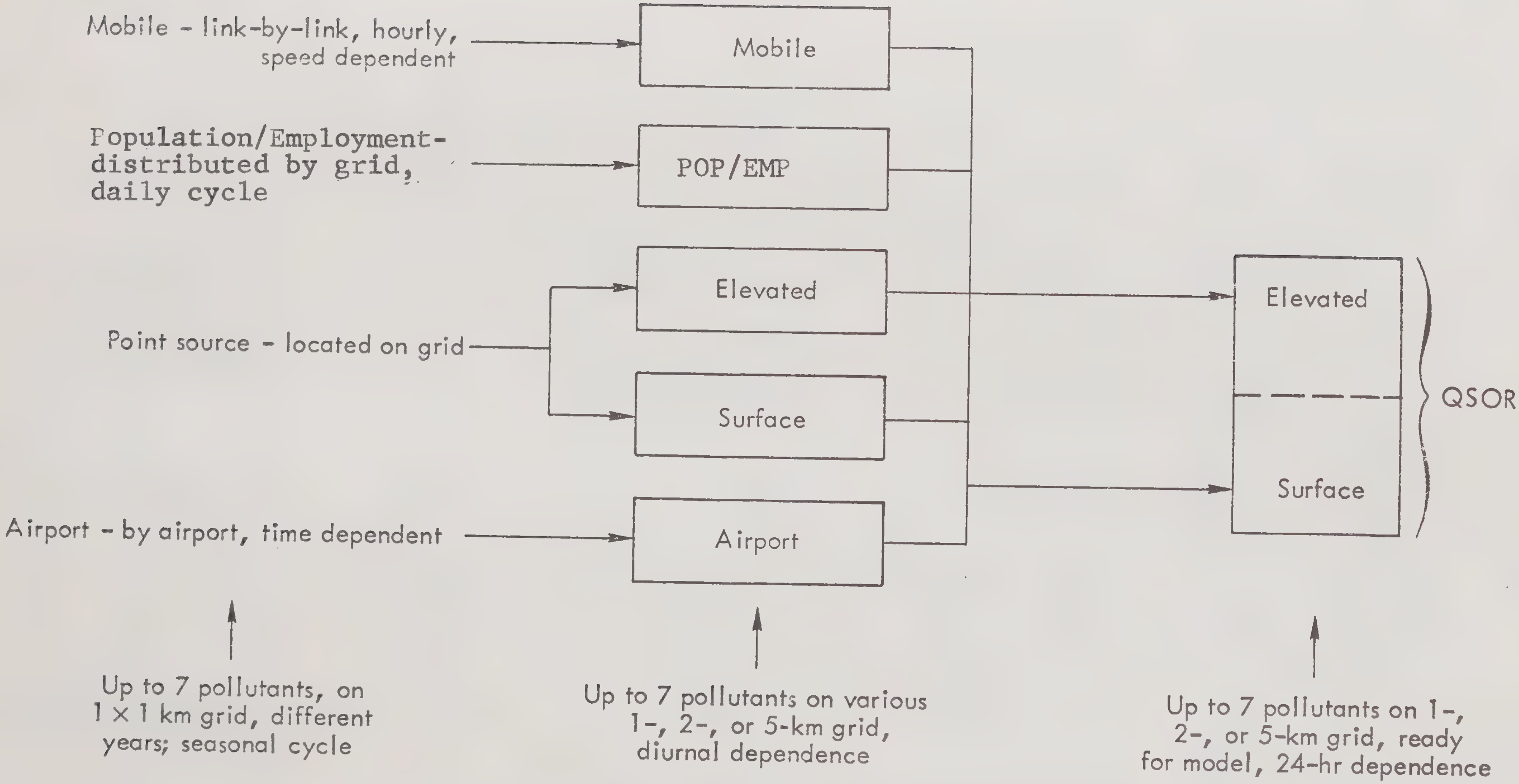


Fig. 1 Steps involved in developing a source emission file for use by the LIRAQ model.

Source: Lawrence Livermore Laboratory

Table 2 - ANNUAL AVERAGE EMISSIONS OF MAJOR POINT SOURCES VS. ANNUAL AVERAGE EMISSIONS OF TOTAL STATIONARY SOURCES (TONS/DAY) - 1975

Source Category	Part.	Org.	NO_x	SO_2	CO
Total Stationary Source	120	530	270	200	410
Total Major Point Source	19	117	162	170	74
Percent	16.0	22.0	60.0	85.0	18.0

The BAAPCD inventory for major point sources is updated annually. For each source, the following data are available: the pollutant or pollutants being emitted, the mean quantity emitted (in tons) during a day, the percent emitted in 30.5 meter (100 ft.) intervals above the ground, the percent emitted by season of the year, the number of days per week of operation (by season), and hours of operation during a day (by season).

After total pollutant emissions for each major point source are assigned manually to the appropriate Universal Transverse Mercator (UTM) grid,[4] the basic data from the BAAPCD will be processed in a straightforward way to produce the major point source portion of the projected emissions source inventory. The mean quantity emitted by a point source during a day will be determined from the total emitted by it annually. Overall data for seasonal, daily, and hourly variation will then be used to determine emission rates for each hour of the day. All emissions at 30.5 m (100 ft.) or more above local topography will be lumped together and will be classified as elevated emissions when the data is processed for use in LIRAQ. A uniform emission rate will be assumed during the hours of operation. Data will be processed to represent weekday emissions only.

AIRPORT SOURCES

There are 43 airports identified in the Bay Area. Of the 43 airports, three are international airports, four are military airports, six are major community airports, and the remainder is small community and private airfields.

Aircraft engines are of two major categories: reciprocating (piston) and gas turbine. The basic element in the aircraft piston engine is the combustion chamber, or cylinder, in which mixtures of fuel and air are burned and from which energy is extracted through a piston and crank mechanism that drives a propeller. The gas turbine engine in general consists of compressor, a combustion chamber,

and a turbine. Air entering the forward end of the engine is compressed and then heated by burning fuel in the combustion chamber. The major portion of the energy in the heated air stream is used for air propulsion.[5]

Based on various reference materials the BAAPCD developed the emission factors by aircraft type and emissions. Calculations were conducted separately for three airport categories: air carrier, general aviation and military airport. 1975 BAAPCD's source inventory for airport sources will be directly used as input for the AQMP source inventory. Detailed methodologies used to calculate emission factors are described in the BAAPCD's 1976 publication "Methodologies and Assumptions for Emissions Calculation." General procedures used for emissions estimates of three types of airports are described in the following section.

1. Air Carrier

1975 BAAPCD's emission estimations for commercial air carrier are based on the number of operations, number of aircraft type and engine, and emission factors. The 1975 monthly number of commercial air carrier operations, which is based on the 1975 North America Air Guide, is provided by the Metropolitan Transportation Commission.[6] This is broken down into numbers of each type of aircrafts and engines for each of 27 types of aircraft based on actual aircraft configurations for three airports.[7] A landing takeoff (LTO) cycle includes all normal operation modes performed by an aircraft between the time it descends through an altitude of 3,500 feet (1,100 meters) on its approach and the time it subsequently reaches the 3,500 foot altitude after takeoff. Each class of aircraft has its own typical LTO cycle. In order to determine emissions, the LTO cycle is separated into five distinct modes: (1) taxi-idle, (2) takeoff, (3) climbout, (4) approach and landing, and (5) taxi-idle. BAAPCD estimated a set of operating time mode for the 3 major airports. The average emission factors of each type of engine now in general commercial use were developed by the BAAPCD primarily based on the EPA's Compilation of Air Pollutant Emission Factors (AP-42) and other various references. There are factors for each contaminant, for each operating mode, and for each type of engine. The days of the month is used to convert monthly emissions to daily emissions.

Estimated emissions for three airports will be distributed equally into land-occupied grids within the 2 mile radius of each airport.

2. General Aviation

The number of operations for general aviation were obtained from ABAG's "Regional Airport System Study." General aviaton jet and turboprop aircraft emissions factors are developed in the same way as commercial air carrier using various sources of information.[8] Piston engine aircraft emission factors are obtained from the "Aviation Effect on Air Quality" study.

Monthly emission variation is estimated based on general aviation activity throughout the year. According to ABAG's "Regional Airport System Study," 40% of total annual operations occurs between

June and September. Using this information 40% of the total number of operations is distributed equally from June to September and the remaining 60% is distributed equally among the remaining months. The days of the month is used to convert monthly emissions to daily emissions.

Estimated emissions from general aviation will be distributed into land-occupied grids within the one mile radius of each airport.

3. Military Airport

Emissions estimates for four military airports are based on the fuel usage data and emission factors. Fuel usage data is obtained from the "Aviation Effect on Air Quality" study. Emission factors are developed from emission data for air carrier operations for the three major commercial airports in the Bay Area. Table 3 presents the emission factors for both jet and piston engines developed in 1973.

Table 3 - EMISSION FACTORS FOR JET AND PISTON ENGINES BASED ON FUEL USAGE (POUNDS PER 1000 GALLONS)

Aircraft Type	Part.	Org.	NO_2	SO_2	CO
Jet	51.2	78.2	55.8	7.9	147
Piston	1.2	49.6	4.7	0	245

Source: BAAPCD

Due to lack of information, monthly variation of emissions are held constant throughout the year. Estimated emissions will be equally distributed into land-occupied grids within the two mile radius of each airport.

NON-MAJOR POINT SOURCES

The 1975 Source Inventory of the BAAPCD estimates emissions for each of the nine Bay Area counties from all non-vehicular sources within that county. In order to determine non-major point sources, it is necessary to subtract emissions due to airports and major point sources from the county. The remaining emissions would be non-major point sources. The county total of non-major point sources has to be distributed into 1x1 km grid elements using the most appropriate variables.

The BAAPCD staff has computed emissions of 107 air pollution source categories by annual average and by county for the year 1975. Currently, the ABAG staff is in the process of distributing population and employment categories from the Projection, Series 3.

Distribution of the county total of the 1975 non-major point sources into the grid system will be conducted utilizing a cross-classification analysis where the objective is to establish adequate functional relationships between source categories and the land use characteristics where the sources originated. Cross-classification is a technique in which the change in one variable can be measured when the changes in two or more other variables are accounted for. In this sense, it is not unlike the more widely used multiple regression trechniques. Cross-classification, however, does not rely so heavily on the assumed distribution of the underlying data and, as such, is sometimes referred to as "nonparametric" or distribution-free technique. Essentially, "n" independent variables are stratified into two (or more, say p) appropriate groups, creating a p x n-dimensional matrix. Observations on the dependent variables are then allocated to the various cells of the matrix, based on the known values of the several independent variables, and then averaged. Using this example, a matrix, such as the one shown in Table 4 can be constructed, indicating definite patterns in the relationships between source categories and the land use activities.

Table 4 - CROSS-CLASSIFICATION OF SOURCE CATEGORY AND POPULATION AND EMPLOYMENT

Dependent Variables	Independent Variables							
	Land Activity							
Source Category	Govt.	Pop.	Mfg.	T.C.U.	Whsl.	Ret.	F.I.R.E.	Total
Asphalt Plant	-	x	-	-	-	-	-	x
Service Station	-	-	x	-	x	-	-	x
-	-	-	x	-	-	x	-	x
Actual distribution	-	-	-	-	-	-	-	-
Percentage distrib.	-	-	-	-	-	-	-	100%

Once the percentage (and actual) distribution of a pollutant for source categories is completed, it is necessary to develop a set of equations which will distribute the county total of each pollutant into appropriate grid cells.

Total pollutant emissions for independent variables for each pollutant on the county level will be obtained by summing up emissions under each independent variable. An average per capita emission rate for each independent variable will be obtained by dividing total pollutant emissions by the population in each category. Distribution of each pollutant into grid cells will be accomplished by multiplying the appropriate per capita emission rate by the population in each independent variable category, then summing the contributions for the cell. This procedure can be expressed by the following formula:

$$E_j = \sum_{i=1}^{7} M_{ij} R_i$$

where

E_j	=	Emissions (tons/day) in grid square j
i	=	Land use activity
j	=	Grid square
M_{ij}	=	Number of people in grid; under activity i
R_i	=	Average per capita emission rate for activity i (i.e. tons/day/person)

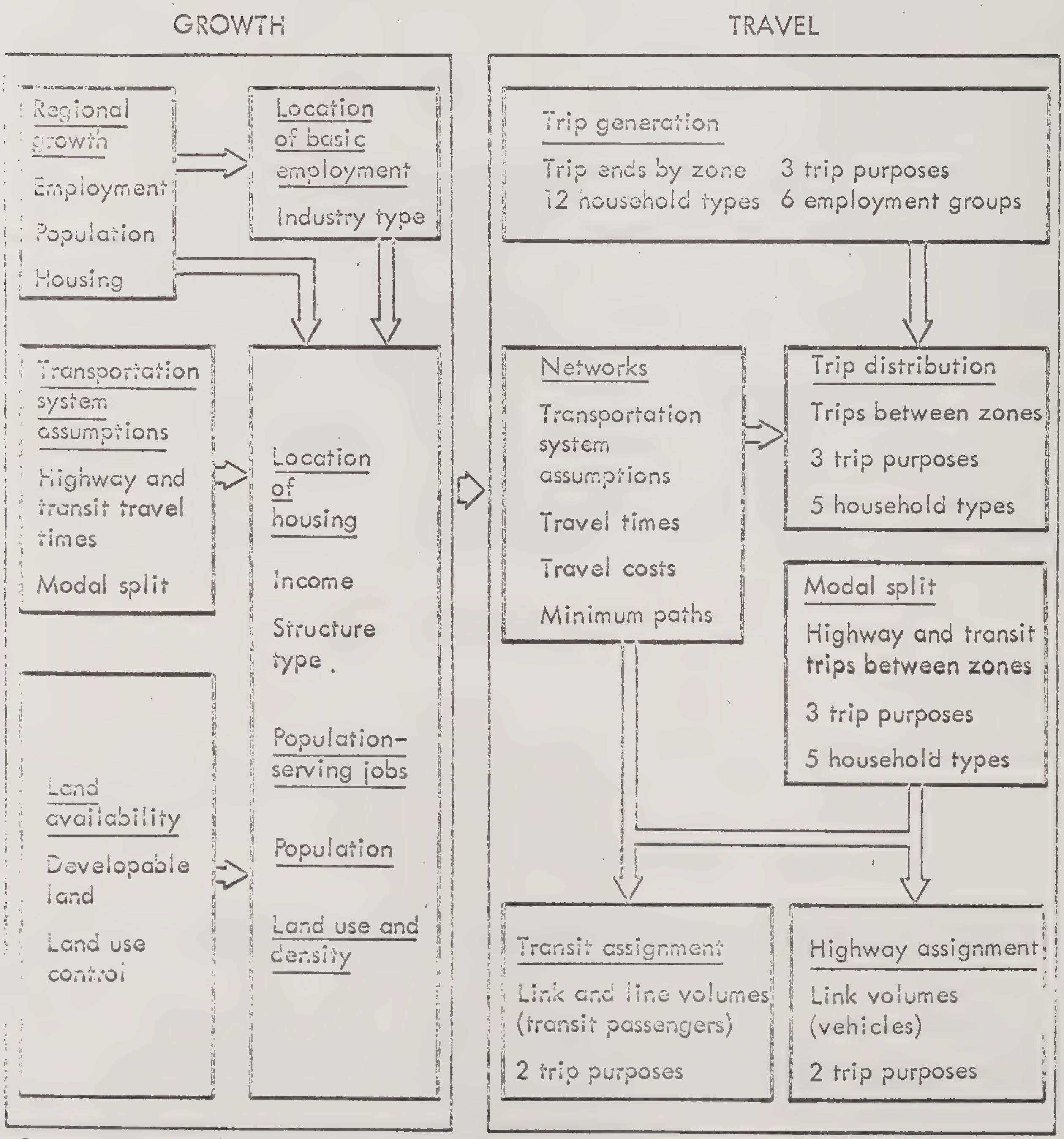
There are, however, certain disadvantages to this technique. It is quite apparent, for example, that the higher the degree of stratification of the variables, the larger the sample must be. Even with an extremely large sample there may be insufficient information to allow accurate distribution over all cells. This is particularly true when the distribution of data will be based primarily on technical judgments. Depending upon the degree of knowledge, the significant relationships might tend to concentrate around a few of the center groups of the stratified independent variables. Despite these apparent limitations, the approach is simple, straightforward, and relatively efficient in its use of basic data.

MOBILE SOURCES

The mobile source inventory's work program is designed and will be executed in two stages, development of the travel pattern model and development of the emission model. MTC will be responsible for developing the base year and future year travel models as inputs to the emission models which will be developed by BAAPCD.

Work tasks of the travel pattern model will include development of the highway network, development of the trip table, and trip loading (trip assignment). During the past years MTC has been developing computerized representations of transit and highway networks, estimating land use development, modeling travel patterns (trip distribution and mode choice), and assigning the travel patterns to the network. The future travel is estimated by MTC using mathematical models based on the future land use and socio-economic characteristics and calibrated by 1965 and 1975 data. This modeling process provides some of the tools necessary to evaluate alternative networks and urban growth configurations. Figure 2 illustrates a schematic relationship of land use and transportation model.

Schematic Diagram for
RELATIONSHIP OF LAND USE AND TRANSPORTATION MODEL



Source: Metropolitan Transportation Commission.

FIGURE 2

Development of the emission model will be primarily based on the emission model AIRMOD, which is developed by BAAPCD. AIRMOD consists of link loading and grid analysis, intrazonal and truck trip model, temporal distribution of mobile source, development of emission factors, and final emission file. Major work tasks for AQMP would be modifications and refinements of existing procedures and input data. Figure 3 describes the flow chart for the 1975 mobile source inventory. The basic modeling flow chart for the emission model is depicted in Figure 4.

1. Link-Grid Analysis and Vehicle Miles Travelled (VMT) Calculation

As a part of the 1975 travel model output, the following data will be provided for each link on the network: average daily traffic volume, length of each link, average driving speeds for peak and off-peak hours, and geographical coordinates for each link (California State Plane Coordinate System).

After traffic volume is assigned to the highway (link loadings), a link-by-link analysis would be conducted to determine the relationship between links and grid areas. Next, the percentage distribution of each link within each corresponding grid area will be determined. Figure 5 illustrates typical cases of links within grid areas and calculations of vehicle miles travelled (VMT) for each grid. Total VMT for each grid element will be obtained by summing the contributions from all links passing through the element.

2. Intrazonal Travel Model and Truck Loadings

Intrazonal trips (both origin and destination of trip is within the same zone), representing local travel, have always been treated lightly in regional transportation planning programs due to their insignificant relation to the regional transportation system. However, recently it has become increasingly apparent that there is a need to develop better tools for estimating the broader dimension of intrazonal vehicle travel. It is especially true with regard to our growing involvement in air quality assessment work. For the mobile source inventory, it became a necessity to develop a program which would be used to calculate total intrazonal trips from total distance and average speed.

Several approaches were examined to develop appropriate indices and stratifiers to enable the coding of a set of "intrazonal links." These can then be built into the network and loaded with the intrazonal trips. For this purpose, "dummy" centroid connectors for each zone will be built and inserted into the network. Distances of "dummy" centroid connectors for each zone will be assumed to be one-half of the shortest path to the zone nearest to the home zone. This method showed a better representation of intrazonal trip distances than several other methods tested. The off-peak travel time on an average local street will be assumed as the intrazonal travel speed.

FLOW CHART FOR 1975 AQMP MOBILE SOURCE INVENTORY

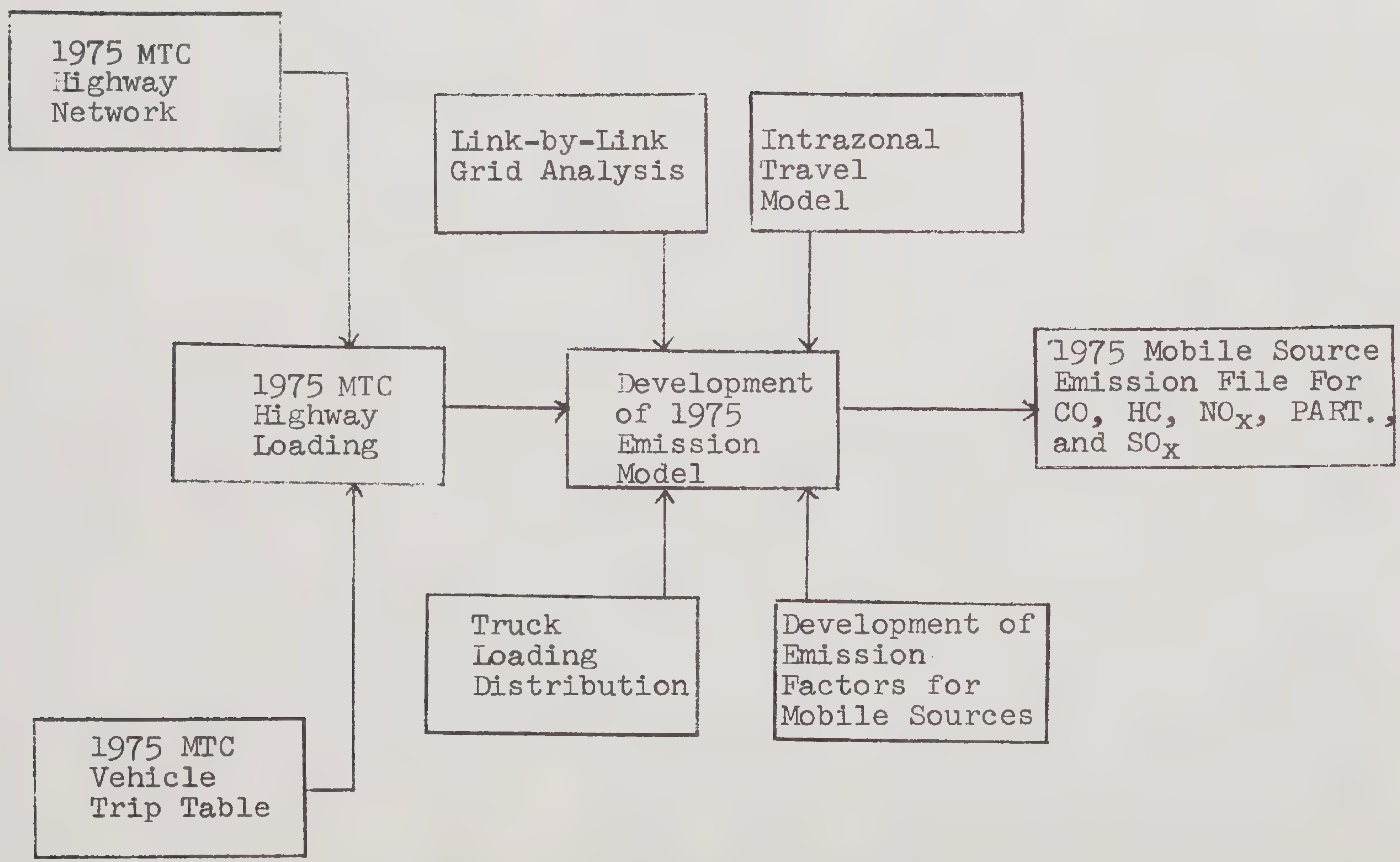


FIGURE 3

MODELLING FLOW CHART FOR MOBILE SOURCE INVENTORY

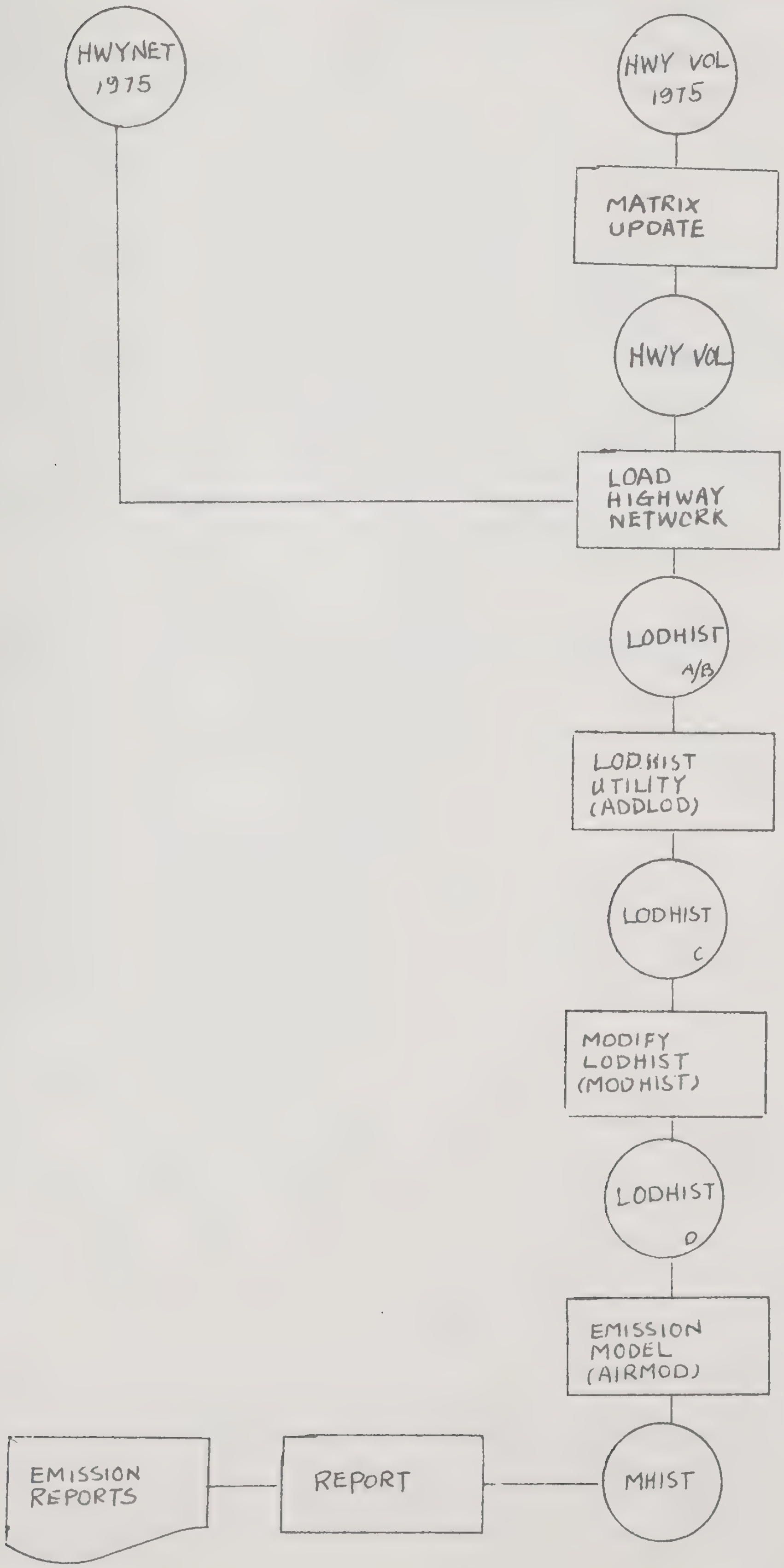
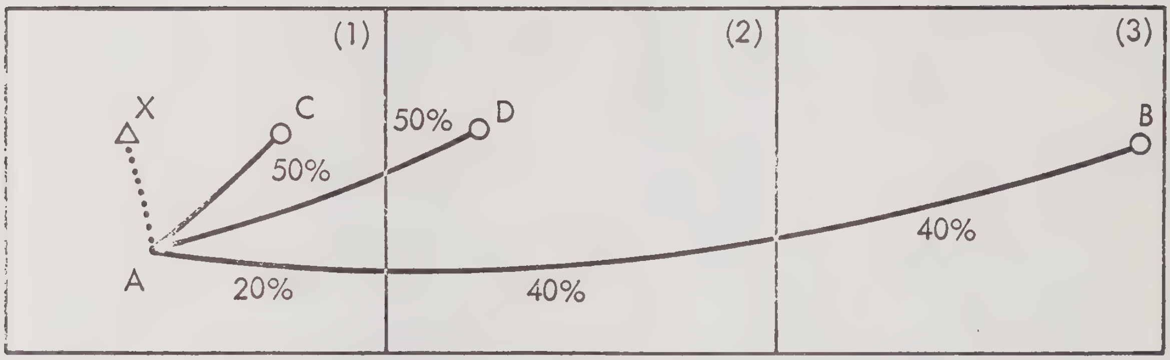


FIGURE 4

VMT GRID APPLICATION ANALYSIS



Information on each link

Link A – B

2 mi
4 min - 30 mph
100 vehicles

Link A – C

0.3 mi
0.3 min - 60 mph
50 vehicles

Link A – D

0.8 mi
1.2 min - 60 mph
2000 vehicles

Link A - X

0.5 mi
1.25 min - 20 mph
200 vehicles

"local" representation

Calculation of vehicle miles/grid square

Grid (1)		Vehicles
0.2 × 2 × 100	=	40
1.0 × 0.3 × 50	=	15
0.5 × 0.8 × 2000	=	800
1.0 × 0.5 × 200	=	100
		955
Grid (2)		
0.4 × 2 × 100	=	80
0.5 × 0.8 × 2000	=	800
		880
Grid (3)		
0.4 × 2 × 100	=	80

Source: BAAPCD Information Bulletin (1975).

FIGURE 5

The end-product would be a complete load history file, from which we can generate vehicle-mile summaries which represent all of the intrazonal trips. The traffic on the "dummy" intrazonal links will be prorated according to number of population and employment to the grid square specified for each MTC zone.

Truck loading factors on the highway network will be developed from the data generated by the California Department of Transportation (Caltrans). In 1965 and 1972 Caltrans took actual truck loadings on the Bay Area highway system. The survey indicated that the differences on the percentage of trucks on the same facilities in 1965 and 1972 were $\pm$ 4 percent. The percentage of trucks on different facility types and locations varied between 3 and 27 percent in 1972. Analysis indicates that usage of highway facilities by truck transports are a function of location and the pattern will remain constant in the future years because of already-established land use pattern in the Bay Region. Therefore, the actual 1972 measured percentages of truck traffic will be applied to individual links for the 1975 network.

The non-highway truck loading factors will be developed by a cross-sectional analysis on truck trip data from five major metropolitan areas.[9] A preliminary analysis indicates that truck trips on the local streets for the size of the San Francisco metropolitan area ranges between 1.5 and 2.4 percent. Therefore, 2 percent of truck trips is proposed for use for the 1975 non-highway facilities.

3. Temporal Distribution of Vehicle Trips

In developing the vehicular emission model, it is necessary to allocate network emissions to diurnal cycles. Since temporal variation of vehicular emissions is a direct function of hourly traffic volumes, it is necessary to construct hourly variation of average daily trips (ADT).

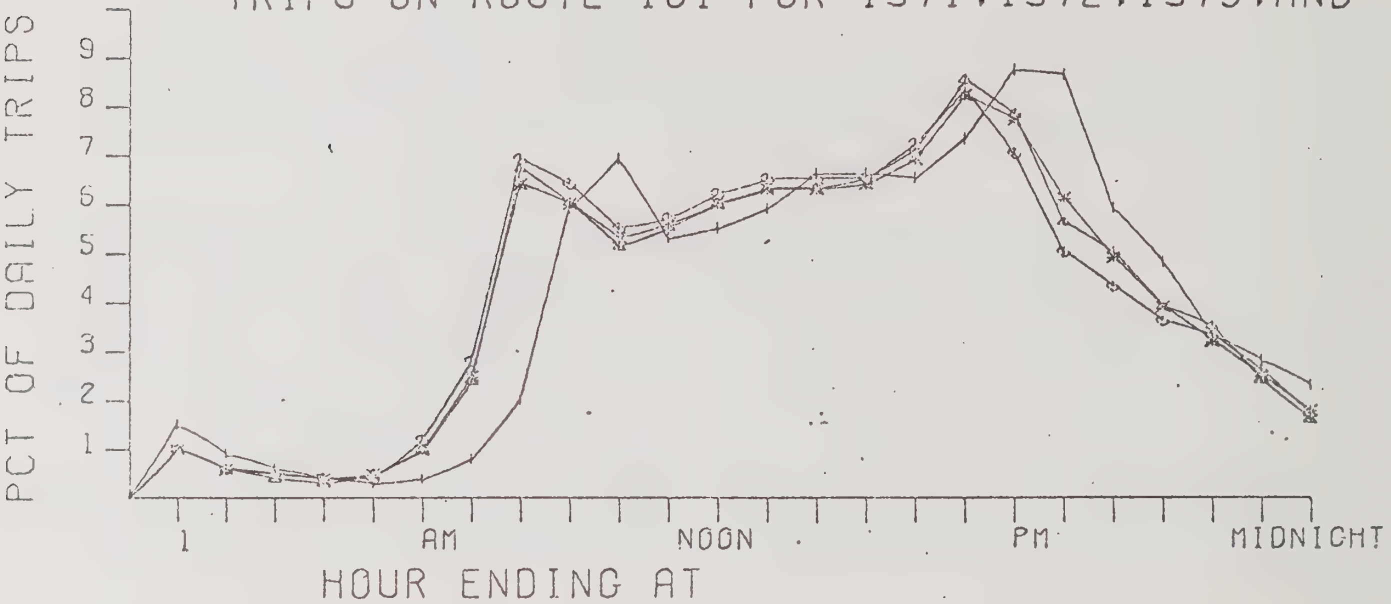
Actual diurnal traffic cycle data on the Bay Area highway network are available from Caltrans. Caltrans maintains three permanent traffic counting stations in the Bay Region. In order to evaluate temporal and spatial fluctuations on traffic cycles, Caltrans's data on three stations for four years (1971-1974) were collected and analyzed. For comparison, the traffic cycles at three stations for the four-year period are shown in Figures 6 through 9. No significant temporal and spatial fluctuations were observed. Analysis strongly indicated that traffic cycles are very consistent regardless of space and time.

The 1965 Bay Area Transportation Study (BATS)[10] developed an hourly variation of vehicular trips on an average day for the Bay Region. Figure 10 illustrates the regional average driving cycles accounted for in the technical analysis and trip forecast produced by the BATSC study. This data was compared with traffic cycle data and other major cities. No major variations were found except San Francisco. Furthermore, BATS data are consistent with MTC data which

FIGURE 6

HOURLY VARIATION OF VEHICULAR

TRIPS ON ROUTE 101 FOR 1971,1972,1973,AND 1974



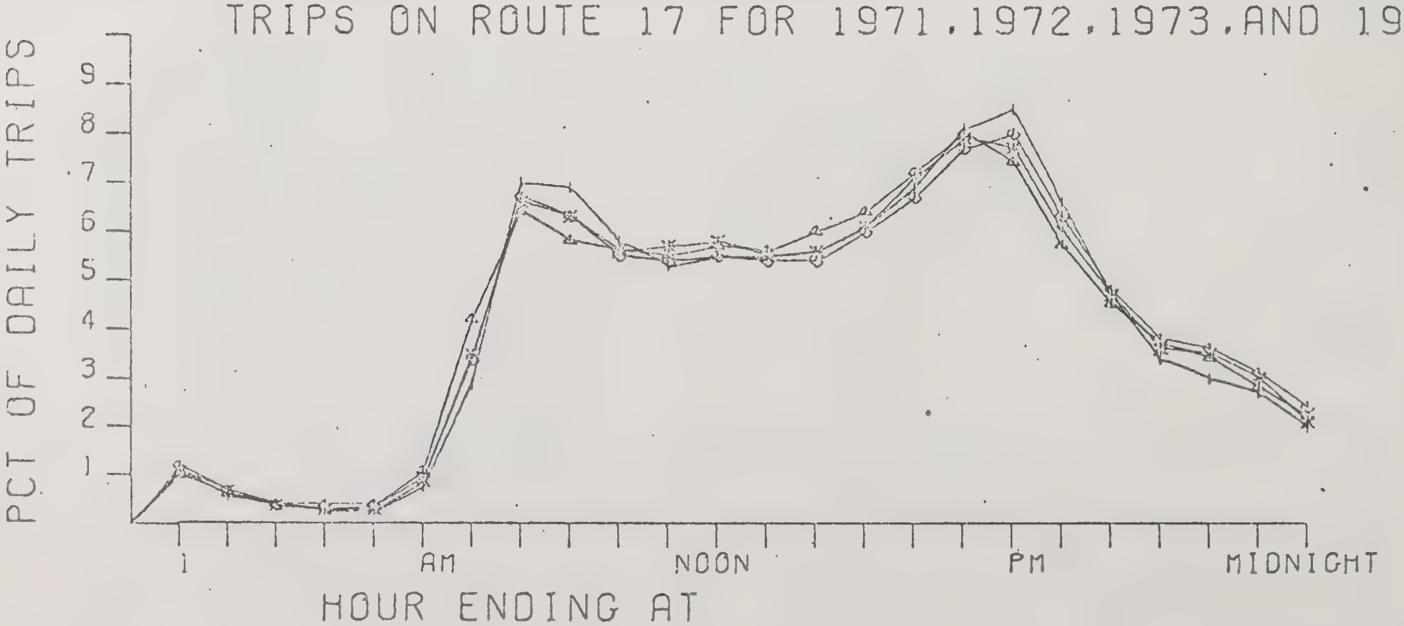
LEGEND - △ = 1971 ✱ = 1972 ◇ = 1973 | = 1974

SOURCE - CALIFORNIA DEPARTMENT OF TRANSPORTATION,DISTRICT 4

FIGURE 7

HOURLY VARIATION OF VEHICULAR

TRIPS ON ROUTE 17 FOR 1971,1972,1973,AND 1974



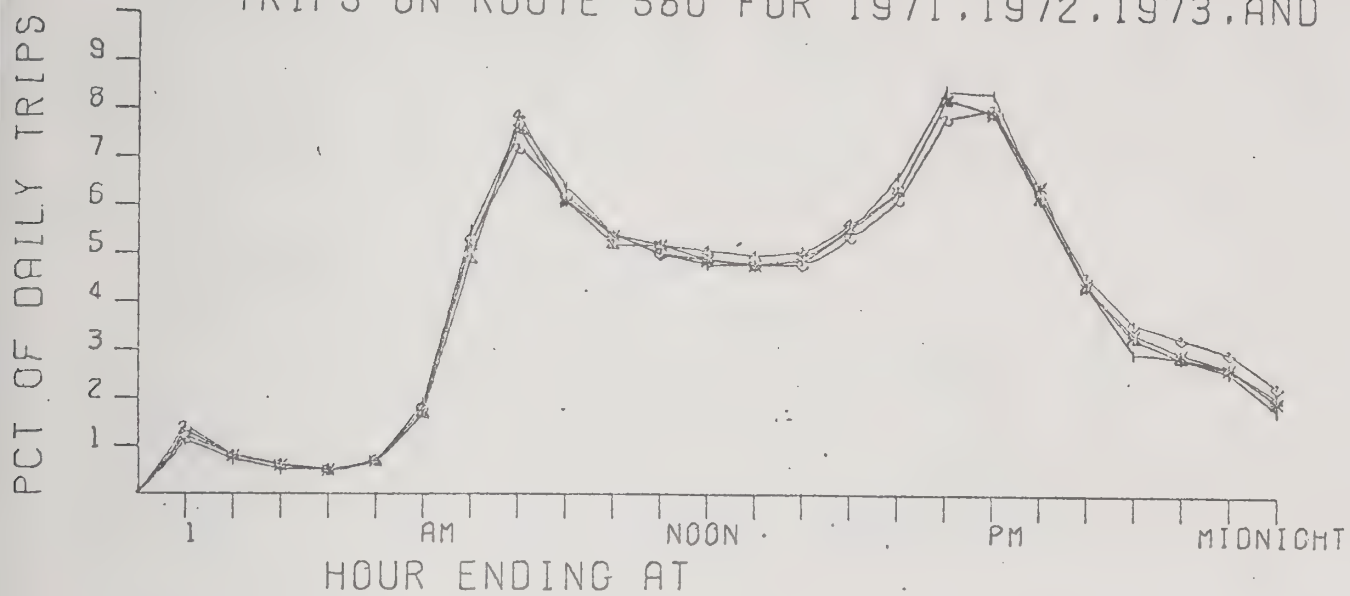
LEGEND - △ = 1971 ✱ = 1972 ◇ = 1973 | = 1974

SOURCE - CALIFORNIA DEPARTMENT OF TRANSPORTATION,DISTRICT 4

FIGURE 8

HOURLY VARIATION OF VEHICULAR

TRIPS ON ROUTE 580 FOR 1971,1972,1973,AND 1974



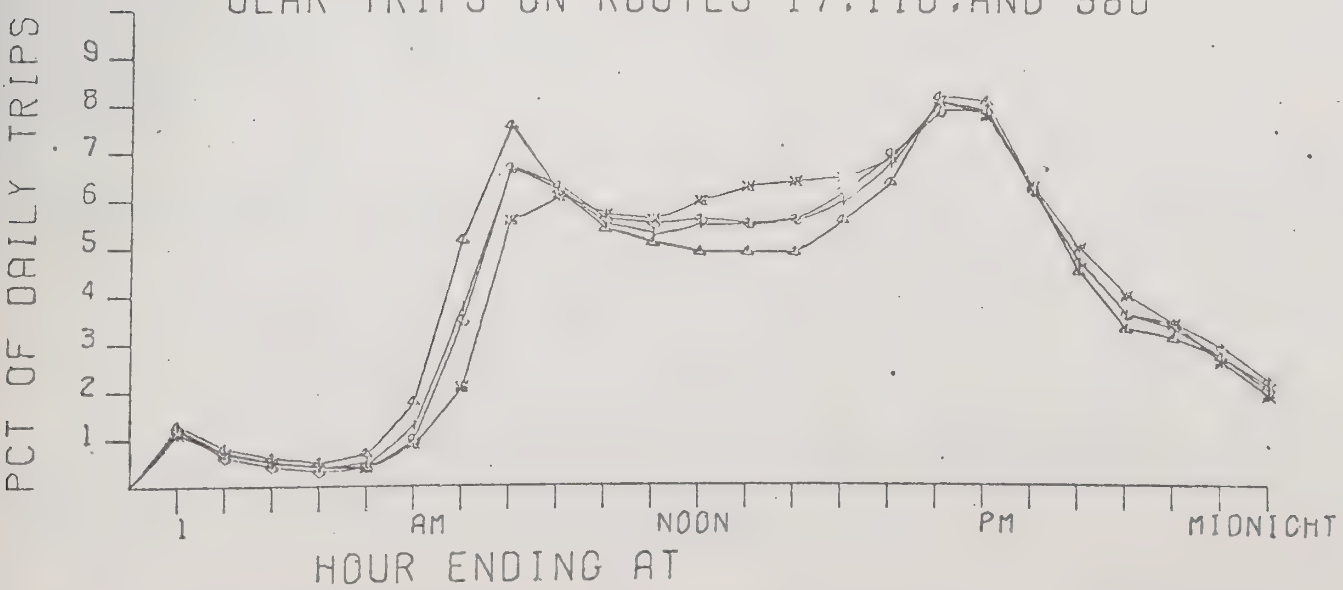
LEGEND - △ = 1971 ✱ = 1972 ◇ = 1973 ı = 1974

SOURCE - CALIFORNIA DEPARTMENT OF TRANSPORTATION,DISTRICT 4

FIGURE 9

HOURLY VARIATION OF 1974 VEHIC

ULAR TRIPS ON ROUTES 17,110,AND 580



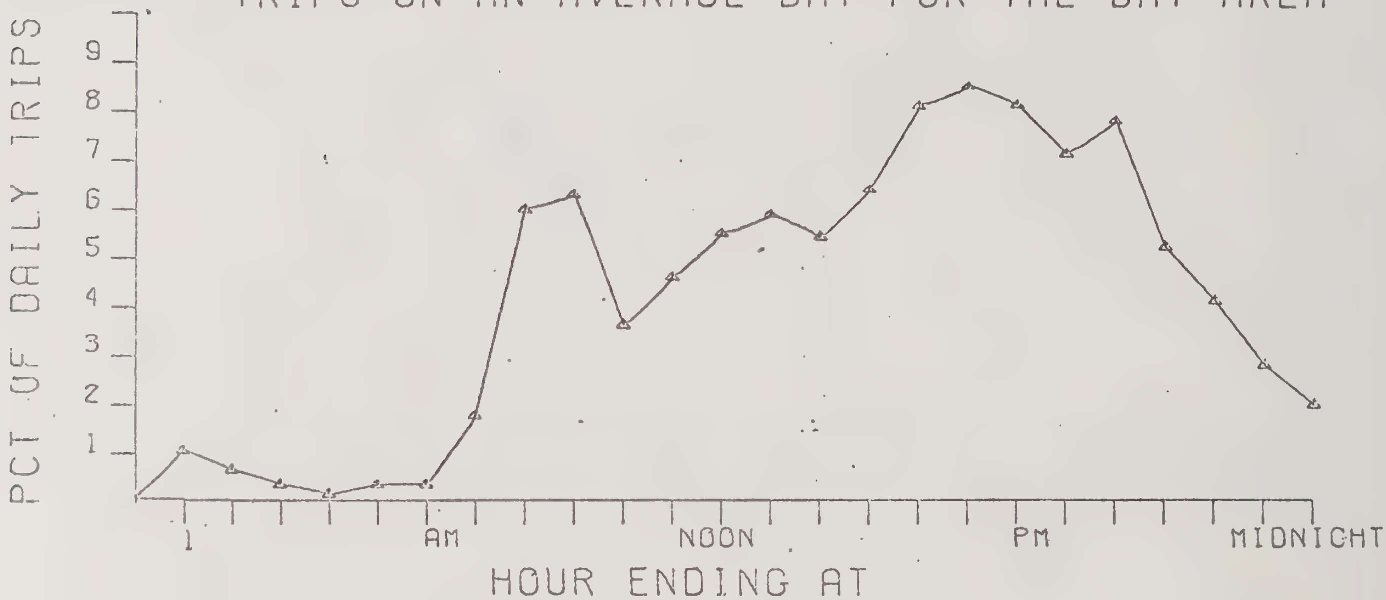
LEGEND - △ = ROUTE 580 ✱ = ROUTE 101 ◇ = ROUTE 17 ı = AVERAGE

SOURCE - CALIFORNIA DEPARTMENT OF TRANSPORTATION,DISTRICT 4

FIGURE 10

HOURLY VARIATION OF VEHICULAR

TRIPS ON AN AVERAGE DAY FOR THE BAY AREA

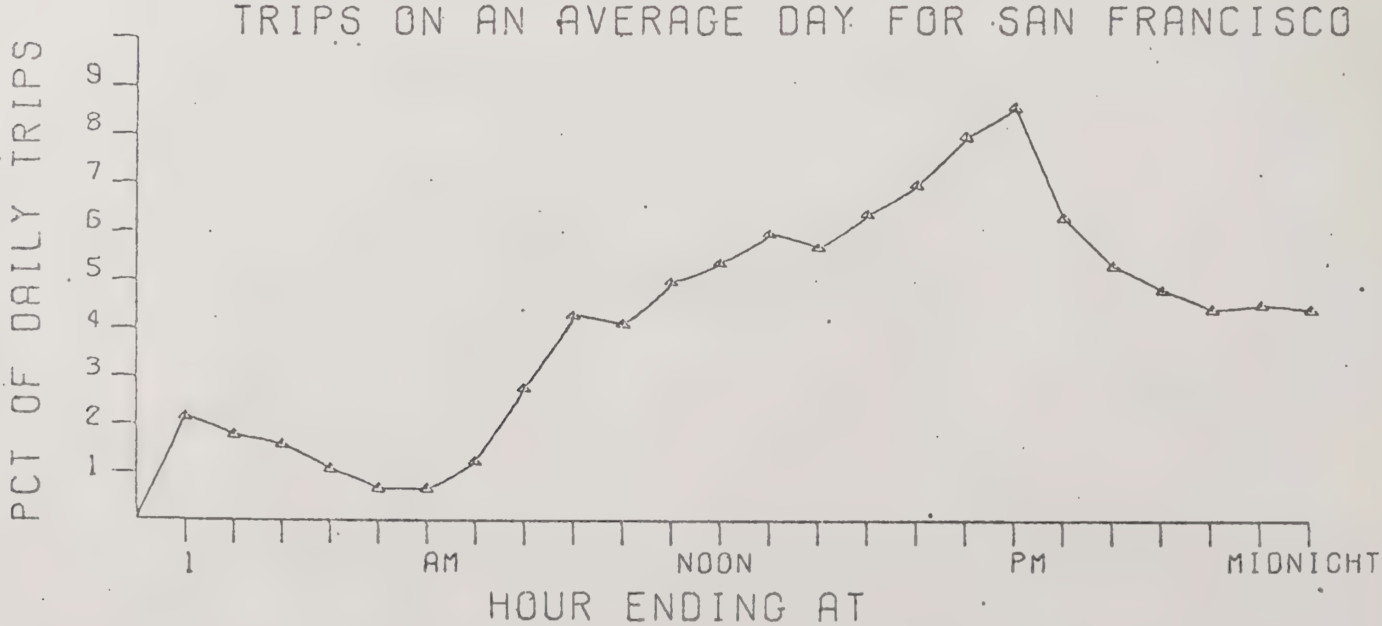


SOURCE - 1965 BAY AREA TRANSPORTATION STUDY

FIGURE 11

HOURLY VARIATION OF VEHICULAR

TRIPS ON AN AVERAGE DAY FOR SAN FRANCISCO



SOURCE - CITY AND COUNTY OF SAN FRANCISCO

will be utilized for the 1975 travel model. For these reasons the traffic cycles curve developed by the BATS will be used for the AQMP study. To calculate hourly traffic volumes, a temporal adjustment factor shown in Figure 10 will be applied to the average daily trips (ADT). Comparable data obtained from the Traffic Department of the City of San Francisco, which is illustrated in Figure 11, will be used for San Francisco.

4. Development of Emission Factors

Since the beginning of the vehicle emissions surveillance testing in 1971, the Environmental Protection Agency (EPA) has been steadily accumulating emissions test data to support advance emission modeling techniques. In December 1975 the EPA published the final report of Supplement No. 5 to the Compilation of Air Pollution Emission Factors (AP-42) describing these advanced techniques.[11] Based on the EPA's AP-42 Supplement No. 5, with few modifications, the Air Resources Board (ARB) developed the mobile source emissions program EMFAC3.[12]

The EMFAC3 program computes composite emission factors for THC, RHC, NO_x, and CO in units of grams per mile. This program will provide emission factor estimates for average route speeds from 5 to 50 mph, ambient temperatures from 20 to 80 degree F, and any desired mix of cold and hot start operation. The output factors may request either a weighted average of the 4 vehicle type emission factors (LDA, LDT, HDG, HDD) which are input by the user or factors for each vehicle type if desired.

ARB's EMFAC3 will be used for mobile source emission factors for the AQMP. However, a number of variables, which vary with geographical location and estimation situation, can affect emissions estimates considerably. The variables of concern include average vehicle speed, ambient temperature, percent of heavy duty vehicle, percentages of cold and hot starts, and percent of travel by vehicle age. Therefore, it is necessary for the AQMP to develop localized emission factors reflecting the above variables as a modification to EMFAC3.

Speed Correction: Emission factors based on the 1975 Federal Testing Procedure (FTP) average conditions apply only to a vehicle mix with 20% of the LDVs driving in cold start operation, 27% in hot start operation, and 53% in hot stabilized operation. Also, the FTP factors are representative for an ambient temperature of 75° F. In addition, the average route speed of the FTP is 19.6 mph. The use of the FTP emission factors without correcting for actual driving conditions may result in large errors in estimating emissions. Speed correction equations for light duty vehicles and heavy duty gas vehicles for speeds from 15 to 45 mph have been developed from research performed by the EPA and Scott Research Laboratory.[13] The Scott curves are used to correct up to 50 mph in EMFAC3.

Corrections for 5 and 10 mph presented in Supplement No. 5 were developed by inputting vehicle operation data into a modal emission analysis model.[14] The results predicted by the model at 5 and 10 mph were divided by the FTP emission factors for hot stabilized operation to obtain the speed correction factors for 5 and 10 mph. The correction factors used in EMFAC3 are based on the correction factors at 5 and 10 mph from the modal analysis and the 15 mph correction factor from Scott Research Laboratories' work for each model year. These 3 points were used to generate smooth hyperbolic curves with a curve fitting program. Therefore, EMFAC3 will correct FTP emissions for speeds from 5 to 50 mph.[12] Figure 12 shows the speed correction curves for post-1970 model year light duty vehicles computed for EMFAC3. Speed correction curves for all gasoline vehicles take this general shape.

Heavy duty diesel speed corrections result from vehicle tests on the San Antonio Road Route. Figure 13 shows the relationship of average speed to emissions. Both speed correction curves will be utilized for developing emission factors for the 1975 AQMP mobile source inventory.

Ambient Temperature Correction: The FTP average temperature is approximately 75°F. Results from a study made by the EPA and the Bureau of Mines indicate that all exhaust emissions are affected significantly by ambient temperature. As ambient temperature decreased, all primary emissions were seen to increase. Vast variances were noted between catalyst and non-catalyst vehicles. The performance of the catalyst is significantly degraded in controlling emissions at low ambient temperature, especially for CO. Figures 14, 15, and 16 show the temperature correction curves for both catalyst and non-catalyst vehicles for CO, NO_x and THC plotted from the functions shown in Supplement No. 5.

As shown in the above figures, the ambient temperature's effect on air quality modeling is very significant, especially for CO. However, a mean summer temperature in the Bay Area ranges from 65°F (San Francisco) to 90°F (Central Valley), depending upon location. Furthermore, three figures indicate that there are few emission changes between ambient temperatures of 65°F and 90°F. Therefore, an ambient temperature of 75°, which is representative of coastal summer temperatures, will be adopted for the study.

Cold Start/Hot Start Correction: The 1975 FTP measures emissions from light duty vehicles during 3 phases of engine operation:

1. Cold Transient (cold start)
2. Hot stabilized
3. Hot transient (hot start)

The cold start phase is representative of a vehicle start-up after a minimum of a 4-hour shutdown for non-catalyst vehicles and a 1-hour

FIGURE 12

SPEED CORRECTION FACTORS FOR POST - 1970 LIGHT DUTY VEHICLES

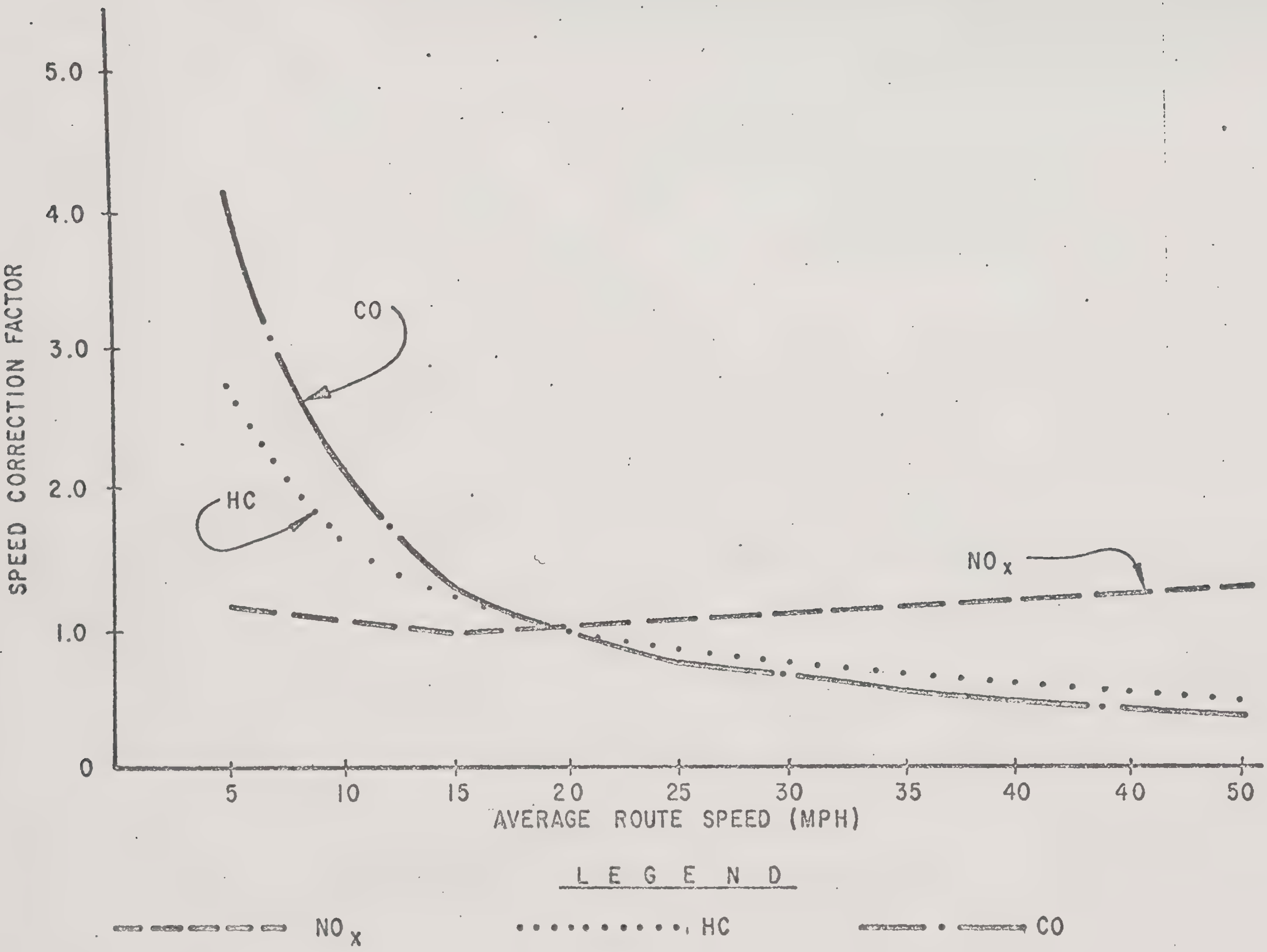


FIGURE 13

SPEED CORRECTION FACTORS FOR HEAVY DUTY DIESELS

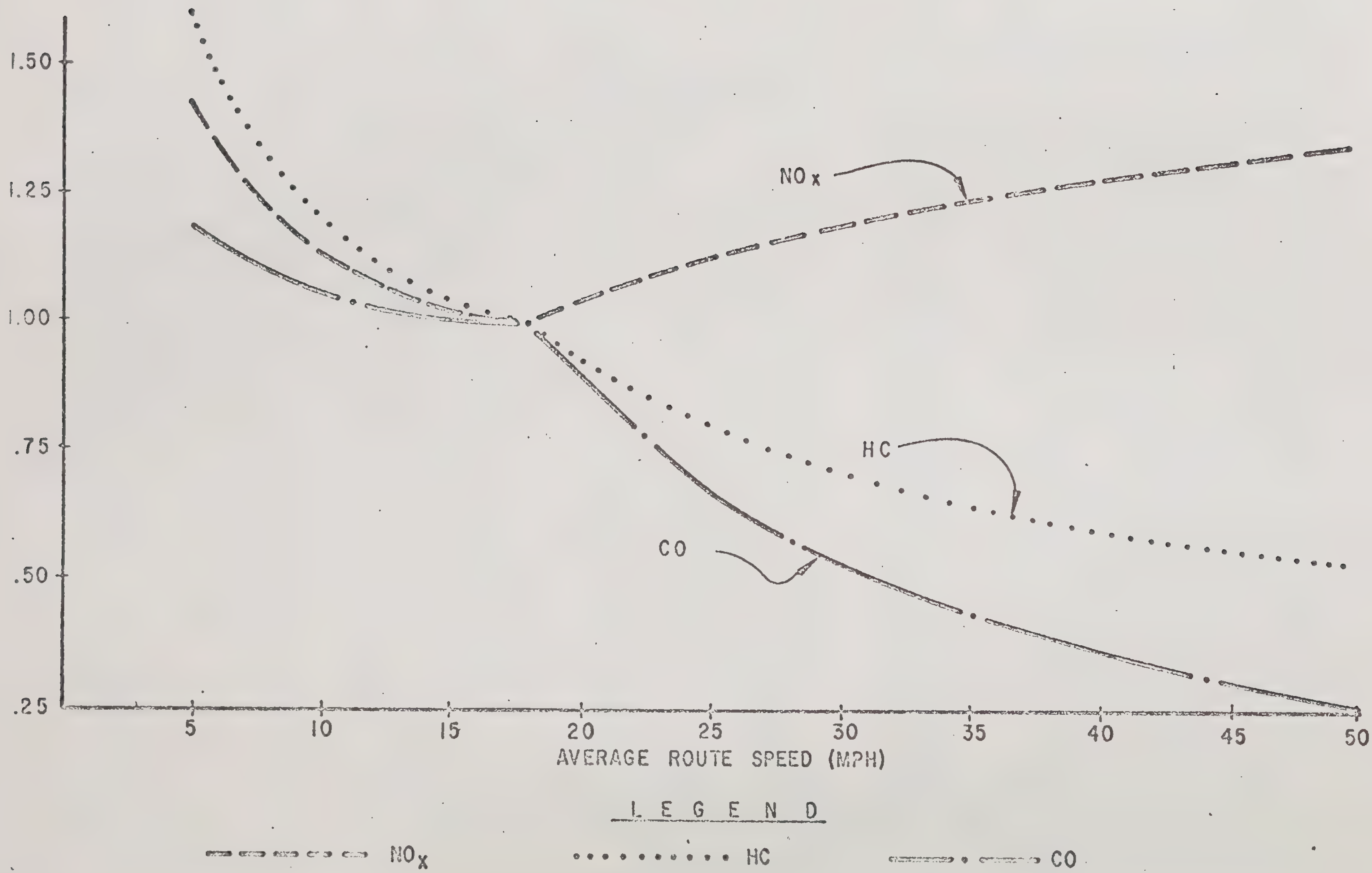
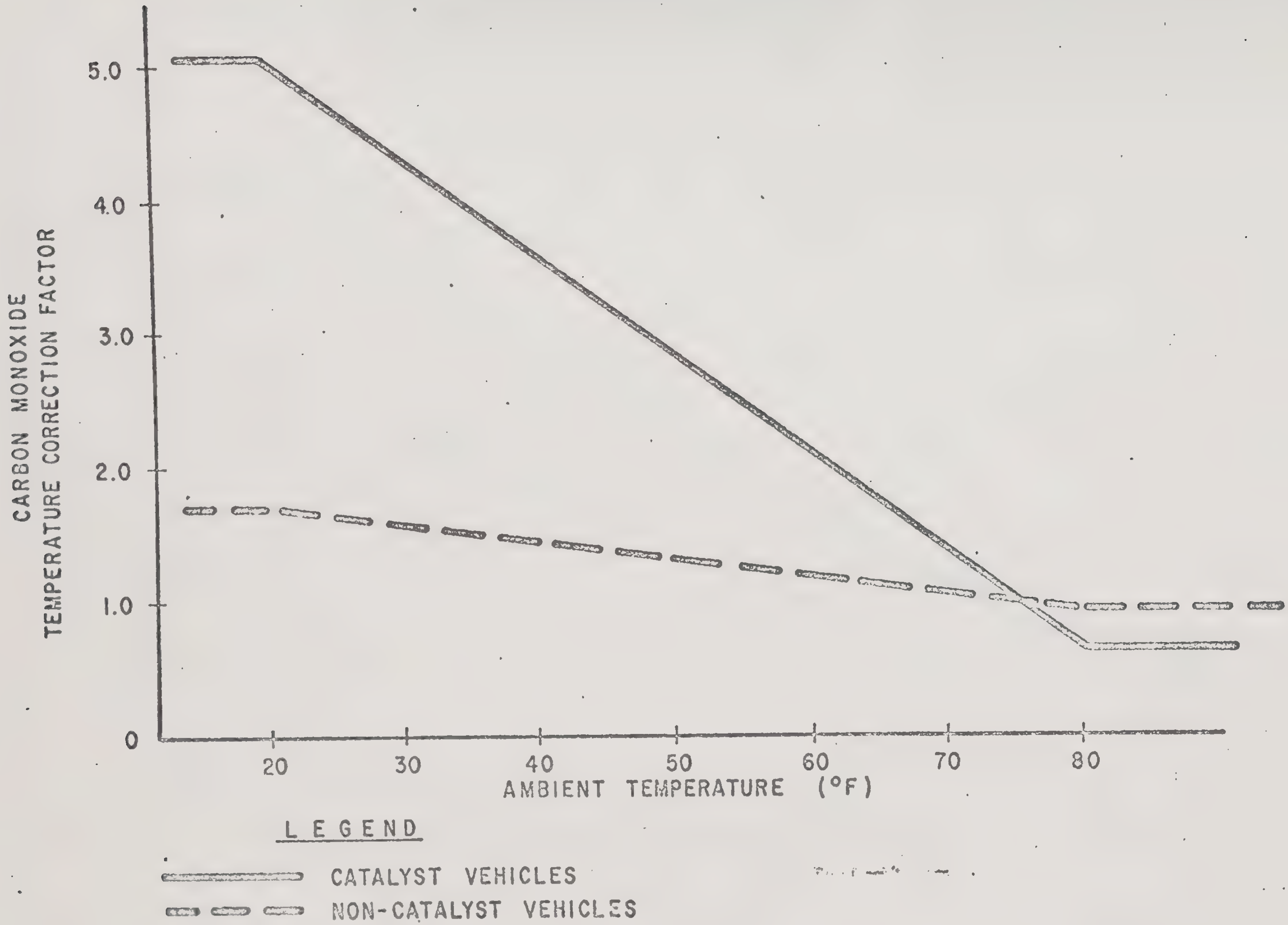


FIGURE 14

CARBON MONOXIDE TEMPERATURE CORRECTIONS FOR LIGHT DUTY VEHICLES



SOURCE: California Air Resource Board

FIGURE 15

HYDROCARBONS (THC) TEMPERATURE CORRECTIONS FOR LIGHT DUTY VEHICLES

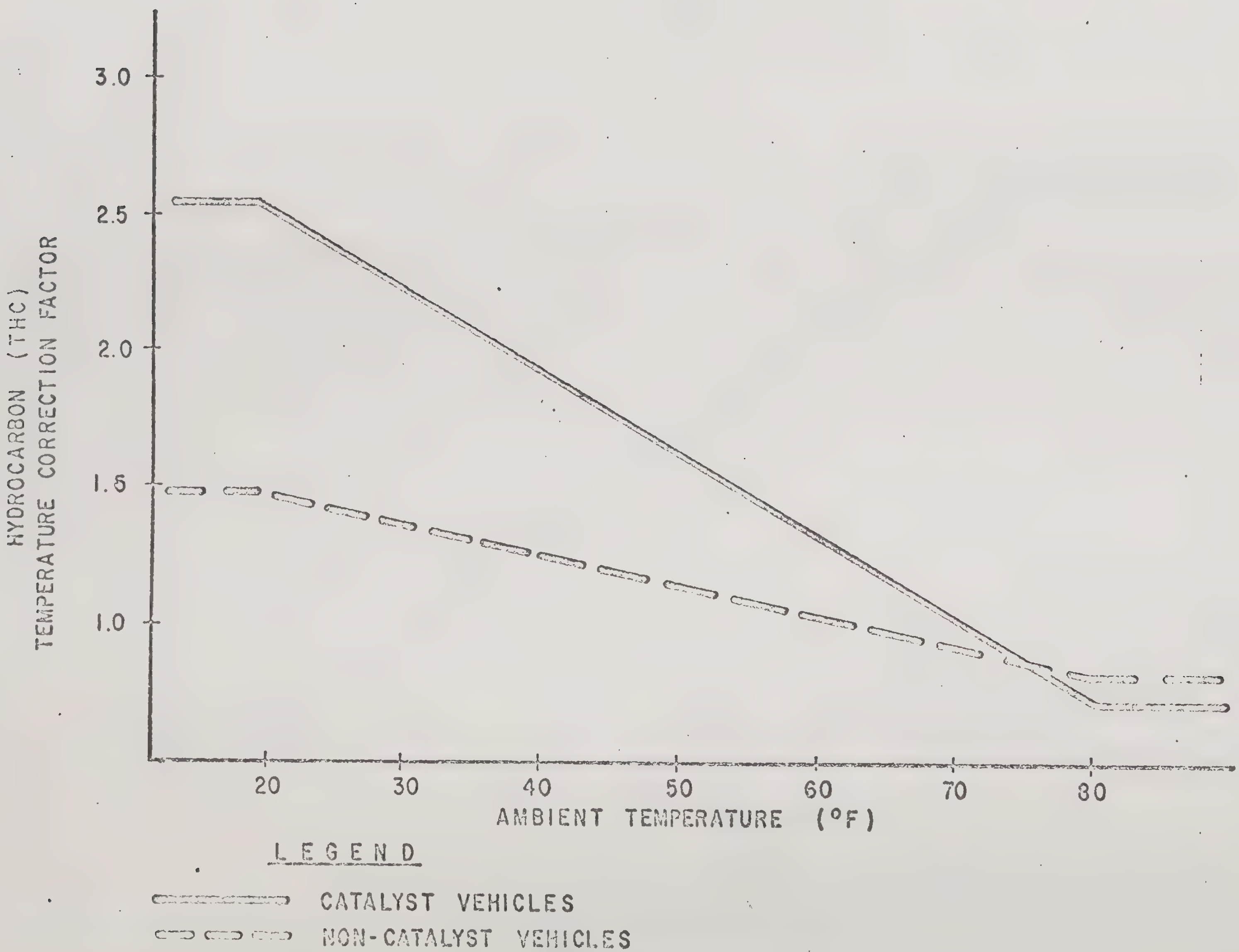
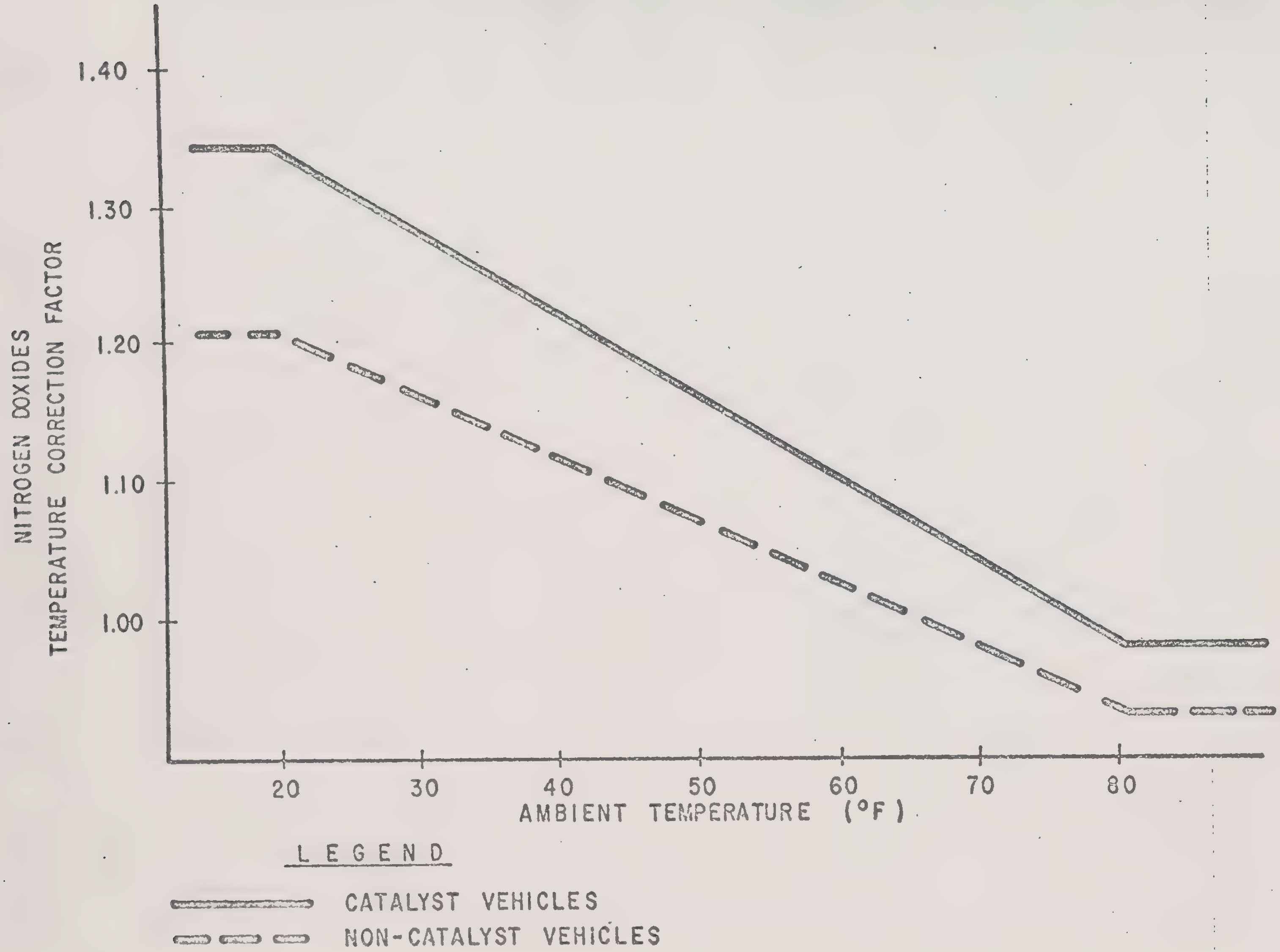


FIGURE 16

NITROGEN OXIDES
TEMPERATURE CORRECTIONS FOR
LIGHT DUTY VEHICLES



shutdown for catalyst vehicles.[11] The weighting factors used to calculate the 1975 FTP emission factors are 20% cold start, 27% hot start, and 53% hot stabilized. Thus, when the 1975 FTP emission factors are applied without any corrections for hot start/cold start percentages, 20% of the light-duty vehicles in the area of interest are assumed to be operating in the cold start phase, 27% in the hot start phase, and 53% in the hot stabilized phase.

For non-catalyst vehicles, emissions in the two hot phases are the same. Cold and hot start correction factors for heavy duty vehicles are not available from the EPA or the ARB at the present. Emission factors from EMFAC3 assume 100% warm-up vehicle operation for both heavy duty gas and heavy duty diesel trucks.

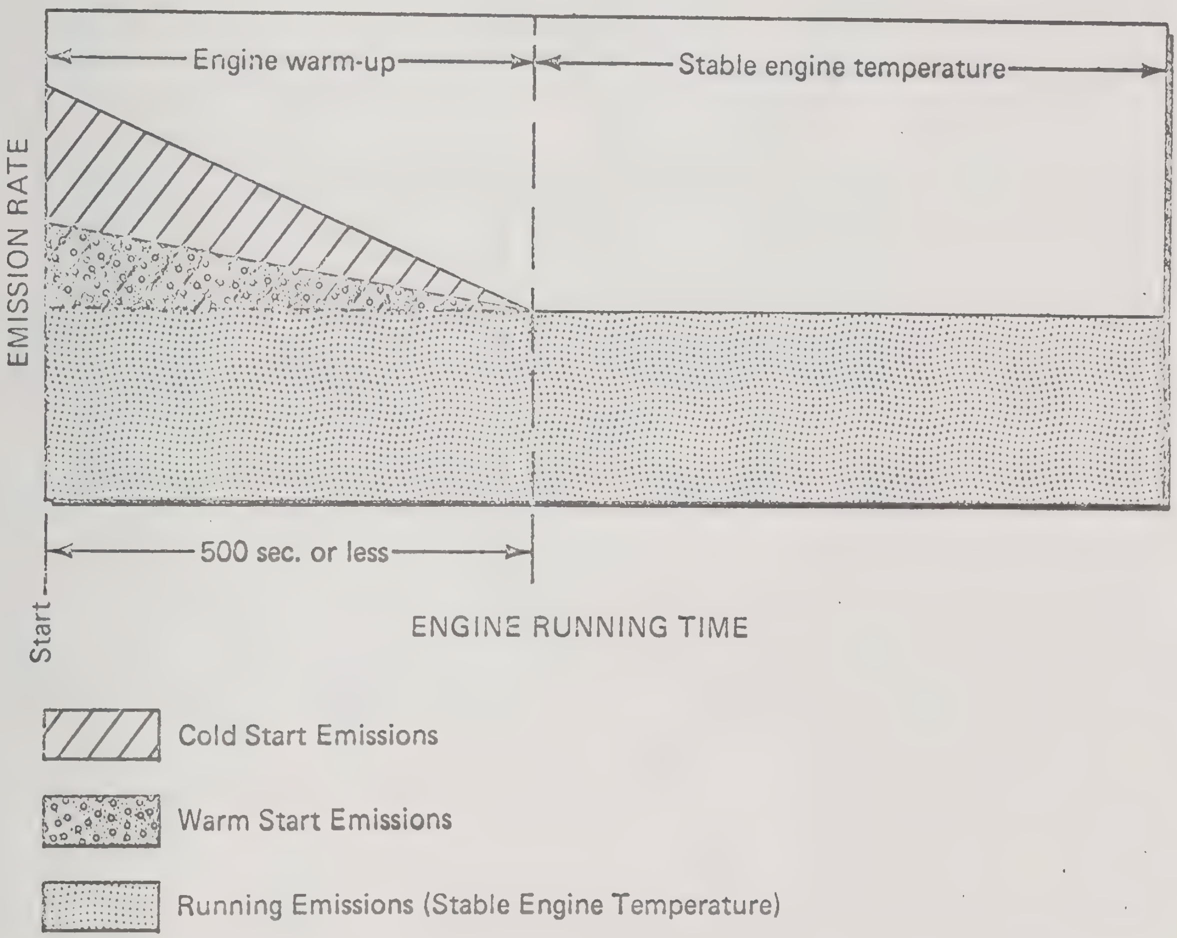
When a vehicle with a cold engine is started up the emission rate during the first few minutes of driving is considerably higher than after the engine temperature has stabilized.[11] This fact holds, regardless of trip length. A short trip produces the same amount of "cold start" emissions as a long trip; the only difference being the quantity produced after the engine has warmed up. Therefore, we can say a portion of the total exhaust emissions produced from motor vehicles is related directly to vehicle trips, not solely to vehicle miles travelled as has typically been assumed. A schematic description of "starting" vs. "running" exhaust emission is shown in Figure 17. This information is important when forecasting motor vehicle emissions and related effects of transportation control tactics. Since some control strategies may not reduce daily vehicle miles travelled proportionately with trips, it is important to separate "trip-related" and "VMT-related" emissions. Table 4 presents motor vehicle emission sources and related activity indicators.

For the AQMP study, the correction factors of zero percent cold start/hot start and 100 percent of hot stabilized condition will first be applied to the highway network traffic. Then, calculations of cold start/hot start emissions for trip-ends of highway traffic will be made separately and calculated emissions will be assigned to trip-end locations. Until better correction factors are developed, the 1975 FTP emissions factors of 20% cold start, 27% hot start, and 53% stabilized condition would be applied to the intrazonal traffic. However, intensive research to develop a more appropriate percentage distribution of the three phases of vehicle operations in the Bay Area is currently underway. Emphasis will be focused on trip frequency and average trip duration by trip purpose in the Bay Area. 1965 BATS survey data and more recent MTC data will be utilized for this purpose.

The end result would be two sets of emission factors with different cold start/hot start corrections for highway and intrazonal networks. Estimated highway network emissions will be distributed into grids based on appropriate highway links and intrazonal emissions will be distributed into grids based on population and employment (location of trip ends).

SCHEMATIC DIAGRAM FOR

STARTING VS. RUNNING EXHAUST EMISSIONS



Source: San Diego Air Quality Planning Team

FIGURE 17

TABLE 5

MOTOR VEHICLE EMISSION SOURCES AND
RELATED ACTIVITY INDICATORS

MOTOR VEHICLE SOURCE	EMISSION SPECIES	ACTIVITY LEVEL	DEFINITION
Running Exhaust	HC, CO, NO_x, SO_x, Part.	VMT	Emissions related to vehicle in motion having engine operating at stabilized temperature.
Starting Exhaust	HC, CO, NO_x, SO_x, Part.	Trips	Emissions related to vehicle in motion with engine operating in transition between cold and stabilized condition.
Hot Soak Evaporative	HC	Trips	Emissions from hot engine after vehicle trip ends.
Diurnal Evaporative	HC	Vehicle Population	Emissions from fuel tank due to expansion of vapors.
Crank Case Blowby	HC	VMT	Emissions originating from combustion but emitted through crankcase rather than exhaust.

Source: San Diego Air Quality Planning Team

"Hot Soak" Emissions: Another important modification to EMFAC3 for AQMP would be "hot soak" emissions. Hydrocarbons are emitted by "hot soak" evaporation for approximately one hour after each trip if the engine is not restarted. A full "hot soak" phase probably occurs at the end of a home-to-work type trip. However, during combinations of several vehicle trip (non-home-based trips), engines are often restarted before a full "hot soak" phase occurs.

EMFAC3 has treated "hot soak" emissions as a part of composite evaporative emissions. The drawback of this approach is that "hot soak" emissions are distributed equally to the entire trip length rather than the locaion of each trip-end. Therefore, for the AQMP study, "hot soak" emissions will be calculated separately and an average duration of "hot soak" phase for all trip types will be determined based on characteristics of all trip types in the Bay Area. Calculated "hot soak" emissions will be distributed into appropriate grids based on trip-end locations.

Mileage Distribution by Vehicle Age: The distribution for mileage driven by each vehicle age category used for EMFAC3 is a state average. In order to reflect local representation, data on vehicle age mix and annual miles driven for the Bay Area will be incorporated in developing vehicle emission factors. The motor vehicle population distribution for the Bay Area is based on 1975 registration data obtained from the Department of Motor Vehicles. Annual miles travelled and percent of each model in the mix are obtained from ARB.

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AQMP/ Tech Memo 3 March 1977

AIR QUALITY: PAST AND PRESENT

For air quality maintenance planning, one first needs a diagnosis of existing problems. A broad regional perspective should cover the major contaminants and their distribution in a representative year. The changes of contaminant levels with time are of major concern, and the varying geographic distributions of contaminants within a region may bring problem areas into sharper focus.

On a national level the contaminants of greatest concern have been sulfur dioxide, suspended particulate, and carbon monoxide. On a state level, the greatest concern has been focused on oxidant, with a corollary concern for nitrogen dioxide. These two are secondary pollutants, not directly emitted but formed in the atmosphere under appropriate weather conditions. (Unfortunately, California's warm summer weather is more favorable to them than to us.)

The EMTF base year of 1975 is indeed a reasonably representative year, balanced between the generally clean well ventilated weather conditions of 1966 and 1972, and the dirty stagnant conditions of 1965, 1969, and 1976. Thus the 1975 data for these five major contaminants have been mapped to show their geographic variation in the Bay Area. These maps then give perspective for brief analytic discussions of each contaminant.

From these 1975 annual summary maps, one may see that the sulfur dioxide maximum is centered in a crescent along the Contra Costa coast, with no impact south of Burlingame. Moreover the annual averages are only 7% of the Federal standard. The total suspended particulate maximum is centered over the Livermore Valley, where the Federal standard is exceeded for 1975, and high values extend to the Santa Clara Valley, where the State standard is exceeded for 1975. For carbon monoxide, the excess "day" maximum is located over downtown San Jose, as a winter evening phenomenon. The nitrogen dioxide annual average maximum is centered over the Santa Clara Valley, reaching 80% of the Federal standard but not exceeding it. For photochemical oxidant, the excess day maximum is centered over the East Santa Clara Valley with an extension to Livermore.

Sulfur dioxide and oxidant levels have decreased significantly over the past decade. Suspended particulate has decreased, but more sporadically because of weather-related non-anthropogenic sources. Carbon monoxide and nitrogen dioxide have decreased overall, but increased in the Santa Clara Valley, because of increased vehicular travel in an area of very limited dispersion.

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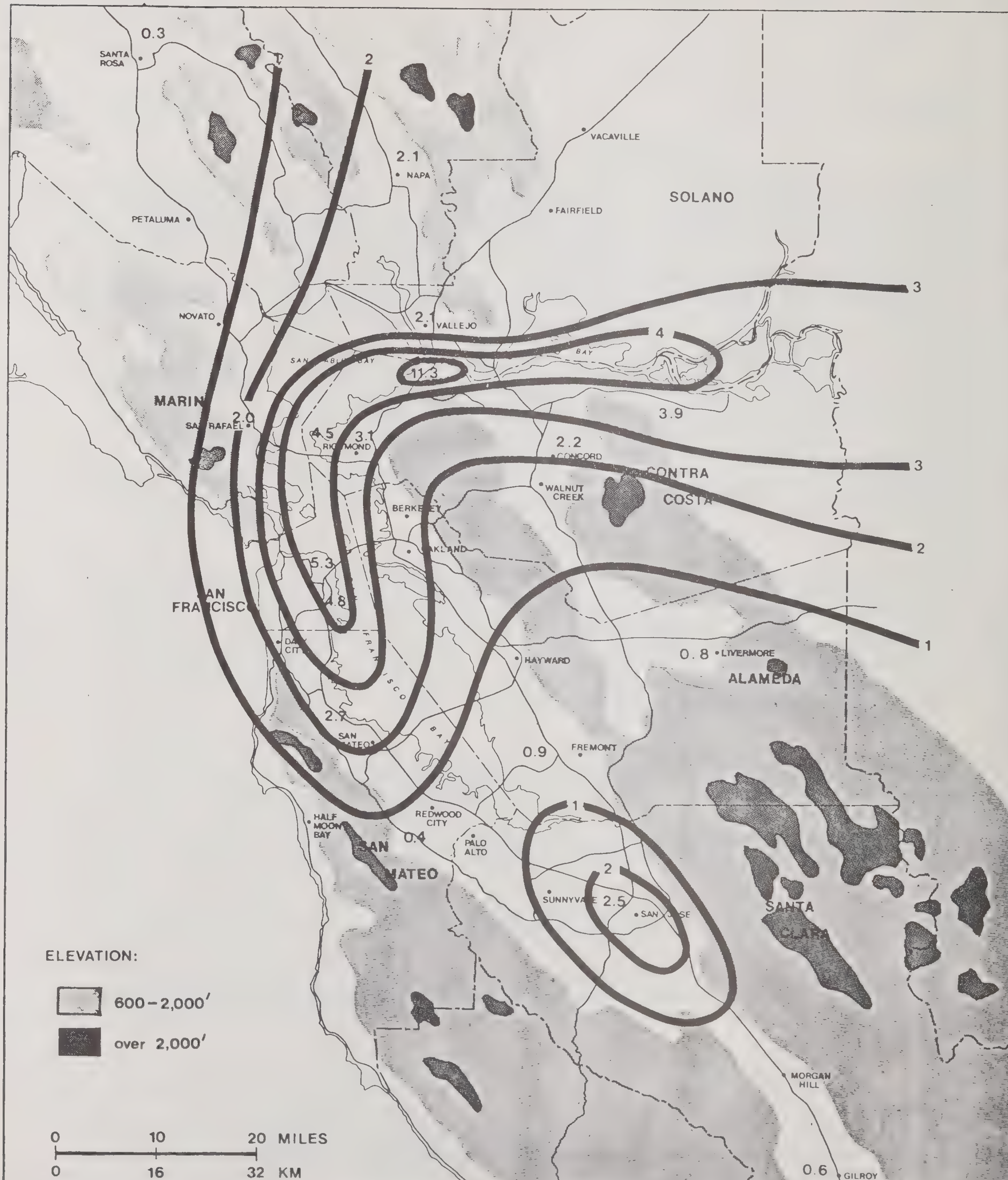
*Prepared by the BAAPCD, Technical Services Division



1975 Annual Average Sulfur Dioxide Values in parts per billion (ppb). Federal standard is 30 ppb.

Figure 1

Sulfur dioxide

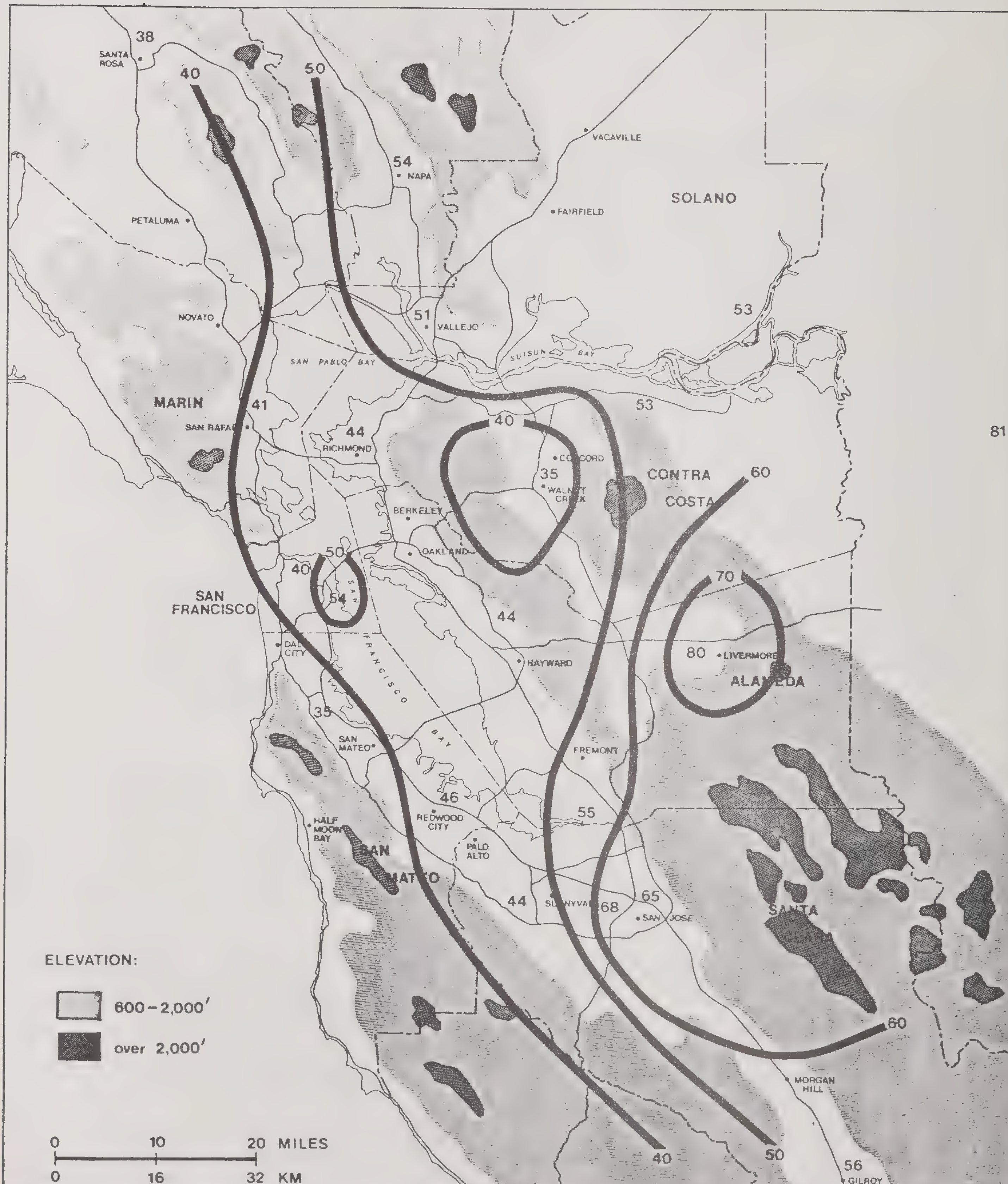
The map of annual average sulfur dioxide values for 1975 shows a relatively narrow band exceeding 3 parts per billion (ppb) centered on the shores of Contra Costa County with extensions to San Francisco Airport and into the Delta. The Federal standard for SO_2 annual average is 30 ppb, thus most of the Bay Area has less than one-tenth the SO_2 levels allowed by the Clean Air Act. The annual average for all District stations is 2.1 ppb, or 7% of the Federal standard.

The District maximum of 11.3 ppb is recorded at Crockett, near a chemical plant which manufactures and ships SO_2 as its major product. Even here the annual levels are 60% below the Federal annual standard and encompass a small largely unpopulated area. The one 1975 excess of the State one-hour standard (.5 ppm, or 500 ppb) occurred at Crockett in July. However, there were numerous excesses of the District 3-minute regulation, which has a time frame 20 times more restrictive than the State standard and 60 times more restrictive than the Federal standard.

This annual average is a composite of varying seasonal patterns. In July and August, for example the highest SO_2 values are at Pittsburg and the Delta, associated with summer airflow patterns. In December and January, drainage flow from the Central Valley along the Contra Costa shore carries the maximum SO_2 averages to San Francisco. A minor secondary maximum over San Jose occurs in September and October, apparently related to local food processing.

The SO_2 in the atmosphere is eventually converted to sulfate after extended residence and travel time, and a State sulfate standard of 25 $\mu g/m^3$ has been established. For 7 years the District has also monitored sulfate and has recorded only one excess of this standard. The pattern of highest sulfate corresponds very closely to that for SO_2, with mean values over 3 $\mu g/m^3$ in an arc along the Contra Costa shoreline.

The 1975 SO_2 average is 63% lower than that for 1969 when this monitoring program began. Despite the energy-related fuel-switch problems of 1973-74, the 3-year average for 1973-75 is 39% lower than that for 1969-71, due to stringent District control of major point sources. Projected decreases in global availability of clean fuels suggest increasing difficulty in maintaining the current low levels of sulfur gases.



1975 Annual Geometric Means of Total Suspended Particulate in $\mu g/m^3$ (by hi-volume method with fiberglass filters). Federal primary standard is 75 $\mu g/m^3$. State standard is 60 $\mu g/m^3$.

Figure 2

Total suspended particulate

The annual geometric means of total suspended particulate (TSP) show a pattern of low values near the coast increasing with distance inland, particularly into dry sheltered valleys. The values are given in micrograms per cubic meter ($\mu g/m^3$) which is a measure of weight. The Federal primary standard, expressed as an annual geometric mean is 75 $\mu g/m^3$ and the State standard is 60 $\mu g/m^3$. In 1975 the Santa Clara and Livermore Valley areas exceeded the State standard, and the Livermore Valley also exceeded the Federal standard.

The most respirable and visibility-reducing particles are very small, with diameters of 0.1 - 0.5 microns (or 0.0000039 - 0.0000197 inches), and their contribution to total weight is small in relationship to their significance. (One 5 micron particle affects the TSP value as much as 1000 of the 0.5 micron particles.) Thus this standard is not an ideal guide to particulate problems. Seven years of District particulate species data show that large silicate particles contribute heavily to the TSP values at our more inland stations such as Livermore.

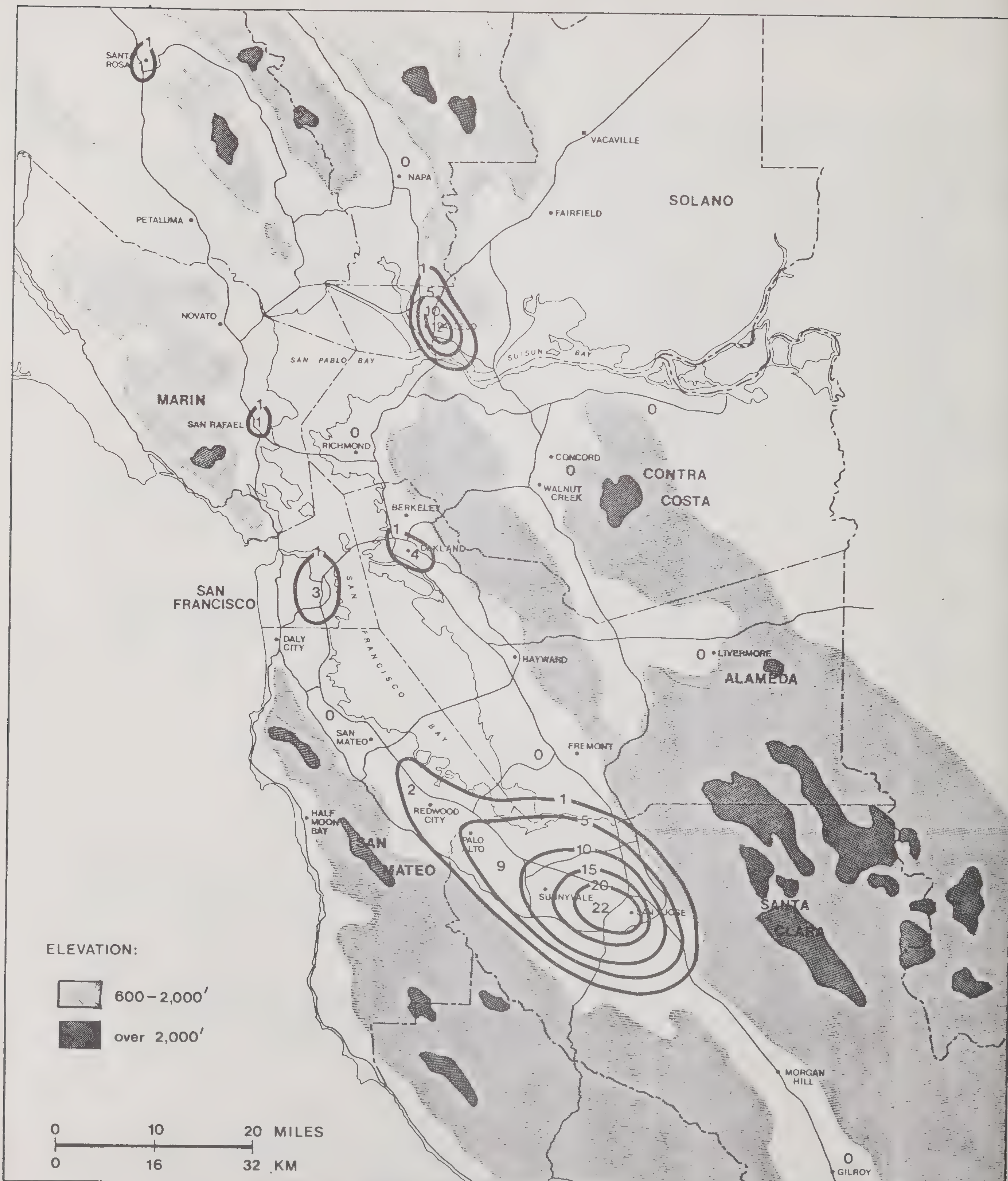
Another widely employed but less precise measure of particulate is the Coefficient of Haze (COH) method, for which no standards have been established, but which relates much better to visibility reduction. Here it is interesting to compare the 1975 COH and TSP annual geometric means for three District stations:

	TSP, AGM	COH, AGM
Sunnyvale	44	0.27
Livermore	80	0.27
Richmond	44	0.14

Sunnyvale has low TSP but high COH, indicating relatively numerous small, but few large particles; Livermore is high in both categories, and Richmond low in both categories. One may hopefully anticipate a Federal standard which better defines the real particulate problem.

One particulate species of particular concern has been lead. The District's annual average lead concentration has fallen from 1.30 $\mu g/m^3$ in 1970 to 0.78 $\mu g/m^3$ in 1975 or a decrease of 40%. The switch to non-leaded gasoline is primarily responsible for this improvement.

This decrease in lead values is not closely reflected in total particulate values, which have varied widely from year to year and station to station although an overall downward trend has been noted. Construction activitites near a station tend to raise its TSP annual geometric mean for that year. Pittsburg, for example, had a TSP mean of 41 in 1972, 65 in 1973 and 50 in 1974, impacted by major construction in 1973.



1975 Annual Number of Days with Carbon Monoxide Exceeding Federal Standard (9 parts per million for 8 hours).

Figure 3

Carbon monoxide

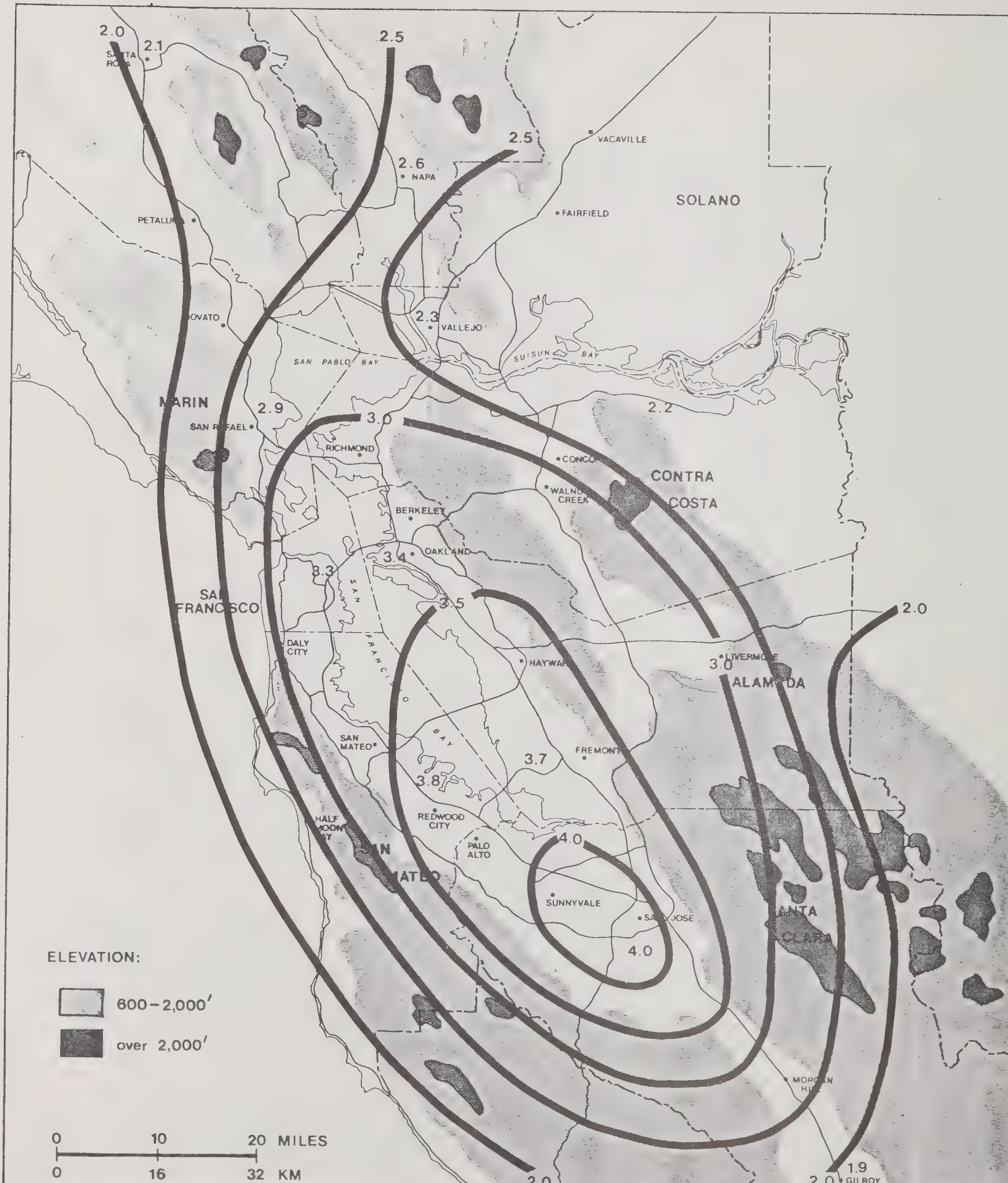
Maps of annual average values as drawn for the previous pollutants are of little value for carbon monoxide, since over 90% of the CO is emitted from vehicular sources resulting in a complex latticed pattern corresponding closely to highway networks. These tail-pipe level emissions are also particularly sensitive to low-level radiation inversions, resulting in very strong daily and seasonal cyclic variations.

Despite the large tonnage of CO emissions, the Federal and State one-hour CO standards have not been exceeded in the current decade. However, the Federal 8-hour average standard of 9 ppm has been frequently exceeded in some areas. The accompanying CO map shows the number of days in 1975 with such excesses. The major excess area is the Santa Clara Valley, centered on San Jose and extending to Sunnyvale. There is a small secondary maximum over Vallejo, and isolated urban-center cases at San Francisco, Oakland, and San Rafael.

To explain this peculiar pattern, one must examine the seasonal and daily cycles in the data. In the past 6 years there has been <u>no</u> CO excess from March through August. Over 80% occur in November, December, and January. On a daily basis over 90% of these 8-hour excesses occur between 4 p.m. and 2 a.m. There is an intense but short maximum from 7 to 9 a.m., followed by low levels from 10 a.m. to 4 p.m. Then, since the winter-season formation of surface-based radiation inversions corresponds to the evening traffic maximum, the sustained build-up of high CO levels occurs. There is also a day-of-week factor, with greatest frequency of excesses on Friday, the maximum vehicle use day. Typically, the District's highest CO values are recorded near 11 p.m. on Friday nights in downtown San Jose. Hopefully, this targeting of the excesses in time and space may suggest the most precise and cost-effective control strategies.

The Santa Clara Valley on a "meso-scale" and our Vallejo station on a "micro-scale" show a strong "drainage pool" effect. That is, the light surface winds under the radiation inversion drain downslope (as water would) and collect pools of contaminants. Our Vallejo station appears to be in such a micro-scale pool impacted by Interstate 80. This effect may have implications for land use planning and highway design.

The District average CO data have shown an 11% decrease from 1970 to 1975. Measured ambient CO levels have decreased less rapidly than total emission, apparently because the ambient values in this air basin are most sensitive to winter evening driving modes and patterns.



1975 Annual Average Nitrogen Dioxide Values in parts per hundred million (pphm). Federal standard is 5.0 pphm.

Figure 4

Nitrogen dioxide

The map of annual average nitrogen dioxide values has the most straightforward pattern of any contaminant, showing a large maximum centered over the Santa Clara Valley. The only Federal NO_2 standard is for the annual average with a limit of 5.0 pphm. The District has never exceeded this Federal NO_2 standard, but San Jose and Sunnyvale are within 80% of it, while Santa Rosa and Gilroy at the lower bounds are near 40% of it.

Nitrogen dioxide is most important as a factor in the photochemical smog formation cycle, but is also a major factor in the dirty brown discoloration of the air. A State one-hour standard of 25 pphm has also been established (near the discoloration level). In 1975 this State standard was exceeded only once - at the Fremont station.

Since the full activation of the District's NO_2 monitoring program in 1968, the District-wide annual average has decreased 11%, but here an examination of individual stations is more elucidating. San Francisco has fallen from 4.0 to 3.3 pphm for a decrease of 18%, but San Jose has risen 3.8 to 4.0 pphm, for an increase of 5%.

The NO_2 develops in the atmosphere from nitric oxide (NO), a primary emission from motor vehicles. An examination of the NO changes helps to explain the NO_2 changes. From 1968 to 1975 the annual NO averages at San Francisco have decreased 49%, while those at San Jose have increased 20%. The Santa Clara Valley now appears to be the principal source area for this contaminant, rather than a receptor area as was more nearly true a decade ago. Independent data of total vehicle-miles by county tend to confirm the current primacy of Santa Clara County.

FIGURE 4.2.8.2

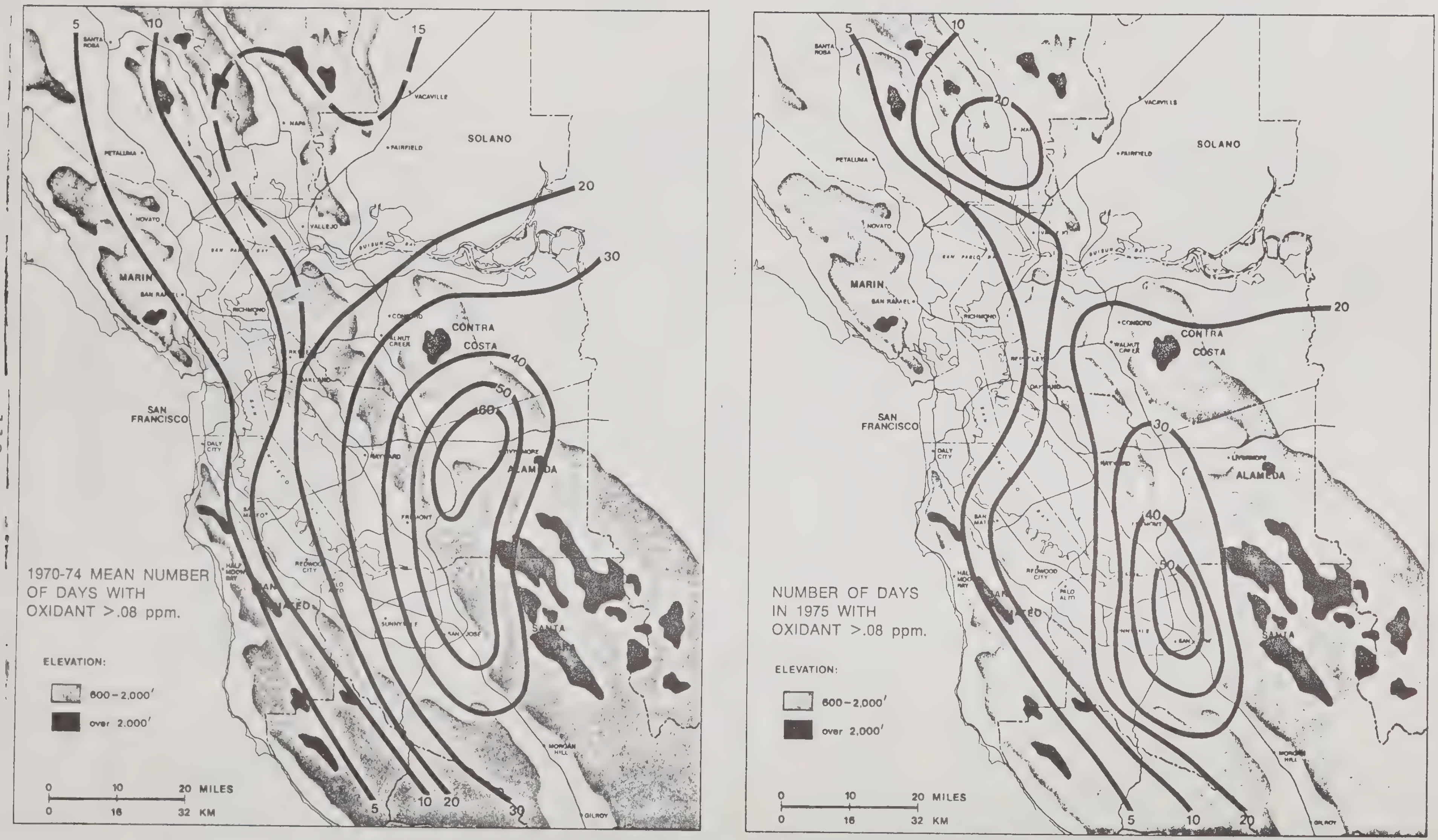


Figure 5a

Oxidant

Photochemical oxidant, as the contaminant of initial and deepest concern in California has now been continuously monitored for 15 years by the BAAPCD. After peaking in 1965, the oxidant levels have shown a clear downward trend for the past 11 years, despite large annual weather-induced fluctuations. Days exceeding the Federal one-hour standard of .08 ppm averaged 131 in the 1965-69 pentad and 85 in the 1970-74 pentad. For the 1975 base year there were 69 days over standard, and preliminary totals for 1976 show 65 days. Despite more than 50% improvement over the past decade, oxidant remains the largest and least tractable problem in terms of air quality maintenance.

For oxidant the accompanying maps plot the number of days over standard in 1975, and for comparison the average values in the 1970-74 pentad. Both maps show minimum excesses (0 to 5 days) along the coast, but in 1975 the clean band had widened and extended further inland. Maximums in both cases are over the inland sheltered valleys, but there are two significant differences. First, the 1975 intensity of the maximum is 20% lower, decreasing from 60 days to 50 days. (Preliminary 1976 data indicates a further weakening of this maximum to less than 35 days.) Second, the center of the maximum has shifted from the Livermore Valley to the East Santa Clara Valley. (Preliminary 1976 data show the center remaining as in 1975, but extending more toward Gilroy then toward Livermore.)

Since the formation of oxidant is highly weather-dependent, the District has developed a "trend study" technique to damp out the primary weather factors (temperature and inversion height) and compare the oxidant levels only for days when these conditions favor its formation. Results of this study (updated to include 1976) are shown in the final graph. On oxidant-conducive days, the District average (for our 7 long-term stations) peaked at .10 ppm in 1965 and has fallen to .06 ppm in 1976. In 1971 this average fell below the Federal standard and has remained below it ever since. The two long-term stations with averages remaining over standard are San Jose and Livermore.

The southeastward migration of highest values over the years is another noteworthy feature of the oxidant trend graph. San Leandro led (with over .15 ppm) in 1964 and 1965; Livermore led (with over .14 ppm) in 1968 and 1969; San Jose led (with .11 to .13 ppm) in 1974 and 1975. These highest station averages have fortunately decreased at nearly the same rate as the overall District average. The reasons for the shift appear quite complex--related to the 15-year shifts in population and vehicle use, and to the changes in emission mix and emission patterns. Additionally, the increases in emissions of primary contaminants have been into the sheltered valleys topographically and meteorologically least favorable for mixing and dispersion.

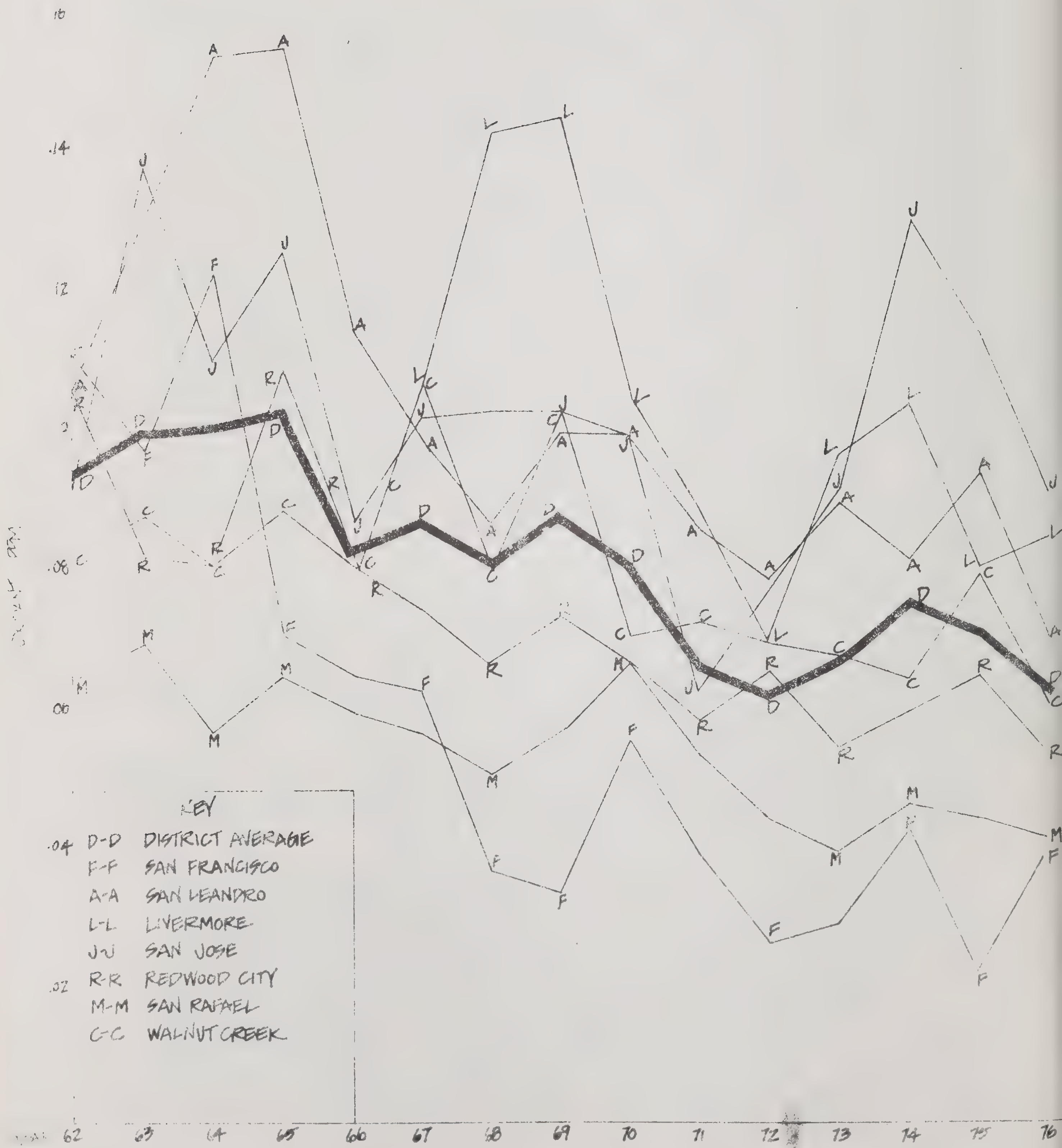


FIGURE 6

[illegible] AVERAGE HIGH HOUR OXIDANT CONCENTRATIONS FOR DAYS WITH COMPARABLE TEMPERATURE AND INVERSION CONDITIONS (APRIL THROUGH OCTOBER PHOTOCHEMICAL OXIDANT SEASONS 1962-1976)

AQMP Tech Memo 4 March 1977

STATUS OF EXISTING CONTROLS RELATED TO AIR POLLUTION

The air pollution problem in the San Francisco Bay Region results primarily from a wide range of human activities. These activities, whether related to our needs for manufactured goods, transportation, or electric power generation, produce emissions of a variety of pollutants. Each pollutant, in turn, produces a unique set of health hazards, agricultural crop damages, and other effects. Thus, both the number of pollutants and the variety of source types make air pollution control a complex task requiring an equally varied arsenal of regulatory tools. This paper is a summary of existing controls related to air pollution, including direct emission controls, as well as land use and transportation controls. These controls are the foundation upon which the Air Quality Maintenance Plan will be built.

STATIONARY SOURCE EMISSION CONTROLS

In the San Francisco Bay Region, the Bay Area Air Pollution Control District (BAAPCD) has been empowered to control air pollution from stationary sources. Since its formation in 1955, the District has developed air pollution control programs for many categories of stationary sources. The area of juridiction of the BAAPCD is very nearly the same as the AQMP area.

The California State Legislature established the BAAPCD in 1955 and empowered it to establish and execute an effective program for the reduction of air contaminants within the District. The Board of Directors could make and enforce rules and regulations to accomplish the specified purposes. The enabling legislation included the first specific source controls, the regulation of open burning. It also prohibited the discharge of air contaminants which cause a public nuisance.

Summary of District Regulations

To date the Bay Area Air Pollution Control District has enacted eight regulations, and six of these affect stationary sources. Some of them directly control air pollution by limiting the emissions of specific pollutants, either on a mass flow rate or concentration basis. Other regulations indirectly control pollutants by curtailing open burning, new source construction and expansion of existing stationary sources. Some sections deal specifically with emissions of odorous substances and others limit the density of smoke which may be emitted to the atmosphere. The regulations of the BAAPCD have been expanded and modified through the years, and are generally acknowledged to be among the most stringent in the United States. A brief description of present regulations follows.

Regulation One, adopted in March 1957, bans backyard trash burning and dump fires. It lists allowable types of fires and limits agricultural burning to favorable meteorology days designated "burn days" by the District.

Regulation Two, first adopted in May 1960, has eighteen different divisions. It includes controls on particulate matter (smoke particles and dust), sulfur compounds, lead, nitrogen oxides, and odorous substances from industrial and commercial sources. Permit and new source review requirements are also included in Reg. 2. The requirement for vapor recovery systems at service stations is part of the permit regulation.

Particulate matter is controlled by limiting both smoke density and particulate weight. The Ringelmann scale, which establishes gradations of smoke density, is used to evaluate smoke plumes in the field. (Ringelmann 0 is transparent; Ringelmann 5 is complete obscuration.) Presently, Ringelmann 1 (20% obscuration) is the allowable density for smoke. Any visible plume which obscures an inspector's view by more than 20% and for longer than three minutes in any hour is in violation. This ruling applies to black, white and grey plumes, excepting steam plumes or plumes containing water vapor as well as pollutants.

The weight of particulates in an exhaust gas stream, known as "grain loading," is limited to 0.15 grain per standard dry cubic foot (SDCF) of exhaust gas volume for industrial sources and incinerators. In addition, a "process weight" rate rule has been established to limit the weight of particulate emissions as compared to the total weight of material used in a given process. The highest allowable rate is 40 lbs. per hour, regardless of the amount of material processed.

Sources of sulfur dioxide must meet either a 300 ppm limit at the emission point or a ground level concentration limit of 0.5 ppm for three minutes. There are additional stack concentration limits of 0.04 grains of sulfuric acid mist (per SDCF) for sulfuric acid plants. Also, there is a stack concentration limit of 6000 ppm SO_2 for any source which emits more than 200 lb/hr of SO_2. Ships must meet a 2000 ppm stack limit.

Under Regulation Two, ground level concentrations of hydrogen sulfide must be limited to 0.06 ppm for three minutes or 0.03 ppm averaged over one hour, primarily as a means of controlling odor.

Commercial and private incinerators must meet the smoke, particulate, grain loading, SO_2 and H_2S controls mentioned above as well as several special requirements. Emissions of hydrocarbons and carbonyls from incinerators must meet a 25 ppm limitation, and incinerators with a capacity of more than 100 tons per day must meet a grain loading standard of 0.05 grain per SDCF of exhaust gas.

Division 12 of Regulation Two forbids any source to emit more than 15 lbs. of lead per day or to emit lead resulting in a ground level concentration of 1.0 microgram per cubic meter in excess of the background level.

The District's permit requirements, set out in Division 13 of Regulation Two, require anyone wishing to build or expand a source that emits air contaminants to first apply to the BAAPCD for a permit to build, and submit plans and specifications for evaluation by District engineers. Permits to build or modify will be denied if it is determined that the project would not meet any of the District's emission requirements or would cause any air quality standard to be exceeded in the vicinity of the proposed site. A second evaluation is required after the source is built before it can obtain a permit to operate. Division 13 also requires vapor recovery controls for service stations.

Nitrogen oxide emissions from large electrical power plants are controlled under Division 14 of Regulation Two. New or modified operations designed for a maximum heat input of more than 250 million BTU per hour must observe a limitation of 125 ppm when burning natural gas and 225 ppm when burning oil. Units designed for a maximum heat input of 1,750 million BTU per hour or greater must meet limitations of 175 ppm when burning natural gas and 300 ppm when burning oil.

Division 15 established emission limits for odorous substances, including five specific odorous chemical compounds or families of compounds: trimethylamine, phenolic compounds, mercaptans, ammonia and dimethysulfide. The requirements are generally designed to keep emissions at levels which upon normal dilution will be under the odor threshold for the surrounding receptors. One section of Division 15 sets forth specific limitations for total reduced sulfur emissions from kraft pulp mills.

Division 16 prohibits use of liquid or solid fuels of more than 0.5 weight percent sulfur content, if the use of such fuels would result in more than 300 ppm SO_2 in the stack gas. Division 17 requires emission control, equivalent to incineration, at rendering plants and related source operations. Division 18 requires controls equivalent to incineration for asphalt air blowing operations.

Regulation Three, originally promulgated in 1967, was developed to control emissions of organic compounds, in particular "reactive" organics which are relatively quick to react with nitrogen dioxide in the atmosphere and form photochemical oxidant. Olefins, substituted aromatics, branched chain ketones and trichloroethylene are examples of reactive organic compounds controlled under this regulation. Regulation Three affects the formulation, storage, shipment and use of such materials as solvents, paint, gasoline and ink.

Sources must comply either with a basic organics emission limit of 300 ppm total carbon (excluding methane), or mass emission limits which affect certain specified operations. New or modified sources which use complying solvents (those which contain 20% or less reactive organic compounds) must limit the emission of organic materials to 3000 lb/day. Operations using non-complying solvents are limited to 40 lb/day. The emission of organic materials which are heated must be limited to 15 lb/day. In lieu of meeting these requirements sources may elect to make an 85 or 90% overall reduction or emissions, or make changes in procedures or equipment, subject to District approval, which will achieve a similar degree of control.

Regulation Three also requires that any solvent or paint that is sold in containers of one quart or larger must comply by containing less than 20% reactive organics. Non-complying material can be sold to industrial users, who are subject to the basic 300 ppm total carbon emission control.

Other requirements of Regulation Three are designed to compel the use of submerged fill pipes, vapor recovery systems and floating roof tanks for transfer and storage of large quantities of organic materials, so that evaporative loss is minimized.

Regulation Four, June 1971, does not deal with stationary source controls. Now obsolete, it required installation of crankcase emissions control devices on certain automobiles.

Regulation Five, adopted March 21, 1974, defines three levels of air pollution episodes and specifies actions to be taken by the Air Pollution Control Officer. Certain corrective control measures are invoked to discourage further buildup of contaminants in the atmosphere. Included in Reg. 5 is a requirement that source operators submit, in advance, standby plans for reducing emissions during air pollution episodes.

Regulation Six, 1974, does not affect stationary sources. It gives members of the BAAPCD vehicle patrol authority to arrest individuals observed to be violating those provisions of the vehicle code relating to automotive emissions.

Regulation Seven, December 1974, sets emission standards for new or modified sources of air pollution, following EPA guidelines. These sources include fossil fuel power plants, larger incinerators, cement plants, acid plants, refineries, smelters and steel plants.

Regulation Eight, December 1974, establishes limits for the emission of asbestos, beryllium and mercury, defined as hazardous pollutants by the EPA. Sources of asbestos are allowed no visible emissions. The beryllium standard limits emissions to not more than 10 grams per 24-hour period. For mercury the limit is no more than 2300 grams/24 hours.

Because of the historical development process, the present system of regulations has become somewhat unwieldy. A complete reorganization is presently being studied and is expected to make the regulations easier to understand and apply.

Effects of Stationary Source Controls on Emissions

Emissions of four major pollutants have been substantially reduced from 1955 to date, as shown in the table below:

STATIONARY SOURCE EMISSIONS (annual average, tons/day)*

Year	Particulate	Organics	NO_x	SO_2	CO
1955	367	662	138	251	1030
1975	115	485	211	174	130

*BAAPCD Emissions Inventory, Base Year 1975.

Particulate, organics, SO_2, and CO emissions have been reduced significantly since the District began operations in 1955, in spite of increases in population and economic activity. Only NO_x, among the five major pollutants has shown an increase over the years, as a result of increased fuel combustion and, until 1972, lack of control measures.

There has been a general trend towards lower emissions and improved air quality in the Bay Area. The goal of achieving all ambient air quality standards is presently threatened, however, by the shortage of clean-burning natural gas and setbacks in mobile source control programs. The predicted switchover to fuel oils will cause increased emissions of SO_2, particulate and NO_x.

Stationary source controls have become increasingly stringent, especially for new and modified sources. Additional and/or more stringent controls may still be required as part of the effort to achieve ambient air quality standards. Organics emissions, for example, could be substantially reduced through new regulations for solvent use, coating operations, and tankage. Sulfur dioxide could be reduced if effective tail gas units were required on all sulfur plants and acid plants. And if the sulfur content of oil was limited to 0.3 or o.2% there would be decreased SO_2, particulate and NO_x emissions. Such stationary source controls may be required--along with mobile source, transportation, and land use controls--to achieve ambient air quality standards.

MOTOR VEHICLE EMISSION CONTROLS

The Air Resources Board (ARB) is the state agency responsible for coordinating both State and Federal air pollution control programs in California. This responsiblity includes regulation of pollutant emissions from motor vehicles and coordination of local programs for stationary source control.

Due to the severity of air pollution problems in California, the Federal government gives the State the option of enforcing motor vehicle emission standards which are more stringent than Federal emission standards. Thus, while the Environmental Protection Agency takes primary responsibility for motor vehicle emissions control, the ARB can and has adopted and enforced emission standards more stringent than required at the Federal level.*

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*The one exception to this is the ultimate NO_x emission standard of 0.4 grams per mile for automobiles required under the 1970 Amendments to the Federal Clean Air Act. EPA has delayed requirements for attaining this standard while enforcing interim standards which are designed to be progressively more stringent with each model year. Current controversy centers around the interim NO_x standard for the 1979 model year of 1.0 grams per mile, which many auto manufacturers feel cannot be met. Several versions of the new amendments to the Clean Air Act introduced into the legislature last year contained extensions for meeting the 1.0 gm/mi. requirement, but until a new set of amendments are enacted, the 1979 attainment date will apply. ARB has in the meantime adopted the 1.0 gm/mi standard to commence with the 1980 model year, and has thus far not adopted the ultimate 0.4 gm/mi target originally set in the 1970 Clean Air Act.

This paper briefly explains ARB responsibilities for mobile and stationary source control, gives a chronology of ARB actions relating to vehicle emission control, and lists current ARB emission standards. Because stationary sources are the direct jurisdiction of the Bay Area Air Pollution Control District, mobile source control actions will be emphasized.

Background

The State of California has regulated emissions from motor vehicles since 1960, when the Legislature established the Motor Vehicle Pollution Control Board (MVPCB). In 1967 the Mulford-Carrell Air Resources Act created the Air Resources Board, which combined the functions of the MVPCB and the Bureau of Air Sanitation in the State Department of Health. Vehicle emission control regulations take the form of both pollutant specific emission standards and performance requirements for meeting those standards.

While its major responsibility is control of pollution from mobile sources, the ARB also is required to coordinate and oversee local control of stationary source emissions. ARB actions in this regard include defining boundaries for air basins which take into consideration meteorological and geographic conditions as well as political boundaries; adopting ambient air quality standards for each basin; adopting emission standards for all nonvehicular pollution sources as necessary in each basin; and adopting test procedures to measure compliance with state and local nonvehicular emission standards. In addition, the ARB may undertake enforcement activities if, after formal notice and public hearing, the Board determines that the local district has failed to discharge its responsibilities as prescribed by law.

To date, the ARB has not found it necessary to adopt or enforce any stationary source control regulations for the San Francisco Bay Area air basin.

Chronology

1960 - Motor Vehicle Pollution Control Board (MVPCB) created by Legislature to regulate emissions from motor vehicles.

1963 - MVPCB required US-made new cars and heavy-duty gasoline powered vehicles sold in California to have improved crankcase devices which would totally eliminate blowby emissions. A statewide installation and inspection program was also established for used cars.

1965 - New US-made cars sold in California required to have exhaust control systems which reduced HC and CO emissions through leaning of fuel mixtures, increased combustion temperatures and burning of some pollutants in the exhaust. This device, used in addition to crankcase device, reduced HC emissions by 42% and CO by 58%. NO_x emissions increased, however, because of increased combustion temperatures.

1967 - Mulford-Carrell Act created ARB, which replaced MVPCB.

1969 - Exhaust controls required on new heavy-duty gasoline powered vehicles sold in California.

1970 - Progressively more stringent exhaust and evaporative emission control systems required on new cars sold in California. Most stringent controls in the nation. Reduced HC and CO emissions an additional 22% and 14% respectively.

- Auto manufacturers required to begin assembly line exhaust emission testing of representative sample of vehicles to ensure compliance with standards. First such testing in the nation.

- Legislation adopted to insure proper adjustment of emission control equipment on new cars.

- 1971 - NO_x controls required on new cars, bringing NO_x emissions to pre-1966 levels.

- Exhaust emission standards and test procedures adopted for 1973-75 cars.

- 1973 Installation of exhaust control devices on light-duty 1955-65 vehicles begun in the San Francisco Bay Area.

- Gaseous exhaust emission controls required for diesel-powered heavy duty vehicles.

- Assembly line testing required for every light duty vehicle produced for sale in California.

- Installation of NO_x emission control devices mandatory upon change of ownership or first California registration for cars in the San Francisco Bay Area.

- 1975 - Strictest exhaust emission standards in the nation adopted for 1977 cars. Action required Federal permission to set standards more stringent than Federal requirements.

- More stringent emission standards adopted for 1977 model year for heavy duty trucks and buses.

- HC evaporative emissions standards adopted for all new light duty vehicles beginning with 1978 model year. Sealed Housing for Evaporative Determination (SHED) testing procedure adopted to certify compliance with standard.

- HC emission standards adopted for on-road motorcycles manufactured for sale in California beginning with 1978 model year.

- Progressively stricter regulations established to regulate sulfur content of unleaded gasoline.

- 1976 - Specifications adopted for fill pipes and fuel tank openings for 1977 and later cars to make them compatible with gasoline vapor recovery systems.

- Medium duty testing and certification category established for 6,000-8,500 pound gross weight vehicles beginning with 1978 model year.

- California 1977 exhaust emission standards extended through 1981 model year for light and medium duty vehicles. NO_x standard lowered for 1980 and 1981 model years.

- More stringent emissions standards adopted for heavy duty trucks and buses through 1983 and beyond.

- Beginning in 1980, vehicle manufacturers required to make carburetors which are virtually tamperproof to reduce incidence of noncompliance due to deliberate tampering.

Summary

As noted above, the ARB currently has regulations which control emissions from light, medium and heavy duty gasoline powered vehicles, diesel powered trucks and buses, and motorcycles. In addition, the ARB has in effect various regulations and procedures to ensure that emission standards are met.

Table 1. Current State Vehicle Emission Standards

Model Year	Vehicle Category	HC	CO	NO_x
78-	Passenger cars	0.41 gm/mi	9.0	1.5
80-81-	Passenger cars			1.0
78-	Lt. Duty Trucks (All)	0.9	17	2.0
80-	Lt. Duty Trucks (EIW $<$ 4000 lbs)	0.41	9.0	1.5
80-	Lt. Duty Trucks (EIW $\geqslant$ 4000 lbs)	0.50	9.0	2.0
81-	Lt. Duty Trucks (EIW $<$ 4000 lbs)	0.41	9.0	1.0
81-	Lt. Duty Trucks (EIW $\geqslant$ 4000 lbs)	0.50	9.0	1.5
78-80-	Med. Duty Vehicles	0.9	17.0	2.3
81-	Med. Duty Vehicles (EIW $<$ 4000 lbs)	0.41	9.0	1.0
81-	Med. Duty Vehicles (EIW 4000-5999 lbs)	0.50	9.0	1.5
81-	Med. Duty Vehicles (EIW $\geqslant$ 6000 lbs)	0.60	9.0	2.0
78-	Motorcycles	10.0 gm/km		
80-	Motorcycles	5.0	(no standards)	
82-	Motorcycles	1.0		

EIW= Equivalent Inertial Weight

TRANSPORTATION CONTROLS

As previously reviewed, the first efforts to control mobile source emissions concentrated on vehicle hardware controls. The planning and implementation of the program was a Federal and State responsibility. In 1970, amendments to the Federal Clean Air Act were passed which required the States to develop State Implementation Plans to Achieve Air Quality (SIP's).

California submitted a State Implementation Plan in 1972, which was found deficient by EPA. A Transportation Control Plan (TCP) was required to correct this deficiency. When the State defaulted, EPA promulgated a TCP in 1973.

The TCP promulgated by EPA included:

- Gas rationing if standards not attained by 1977.
- Inspection and Maintenance Program.
- Motorcycle limitations.
- Catalyst retrofit (1966-77).
- Surcharge on commercial parking spaces.
- Charge for employee parking with incentives for carpools.
- Management of parking supply.
- Computer carpool matching.
- Other stationary source controls.

The total effect would have reduced the expected 1977 Reactive Hydrocarbon (RHC) emissions due to mobile sources from 201 tons per day to 75. The required reduction in private auto Vehicle Miles of Travel (VMT), however, would have been 97%. As could have been anticipated, this generated considerable adverse public reaction.

The primary failing of the Plan was that it was unrealistic. Under court order, EPA was required to develop a plan that would meet the standards by 1977. Unfortunately, there was no way to do this without virtually "shutting down" the region.

Elements of the EPA Plan are still on the books, although the gas rationing, motorcycle limitations, parking surcharge and parking management portions of the Plan have been dropped.

Substitute TCP

California decided to prepare its own TCP as a substitute for the one submitted by EPA. The Metropolitan Transportation Commission was designated the lead agency for preparing the Bay Area TCP. This Plan was completed in March of 1975, and proposed the following short-term control strategies:

- Improved transit service.
- Reduction of auto traffic entering CBD's and other major generators.
- Selectively intensified RIDES efforts (carpool matching program).
- Additional Park-and-Ride fringe parking.
- Suburban employer subscription bus and carpool program.
- High occupancy vehicle lanes.
- Operations/Management study.
- Gas tax increase (one cent).
- Bay Bridge revenue excess for transit.
- Local transit preferential measures.
- Bicycle incentives.
- Preparation of Parking Management Plan.

The combination of these strategies was estimated to reduce VMT in the region by 7% and Reactive Hydrocarbons by 5.8 tons/day. It was recognized that drastic measures would be required to meet the Standards by 1977. Thus, the proposed TCP did not attempt to meet this deadline, but instead presented a realistic alternative.

Parking Management Plan (PMP)

As originally conceived in November 1974, the objective of the Parking Management Plan regulations as an element of the Transportation Control Plan (TCP) was to reduce vehicle travel and automotive pollution by managing the amount, location, type and price of parking in the urban areas. The San Francisco Bay Area Region was one of fifteen urban areas which were required to prepare a PMP. Several revisions and modifications were made to the initial proposed regulations and ultimately, on July 15, 1975, the parking management regulations were suspended indefinitely "pending further Congressional guidance."

The MTC parking management study involved detailed analysis and evaluation of parking control measures. The results of the analysis have demonstrated that parking controls can be effective in modifying travel behavior and reducing the amount of pollutant emissions emitted by automobiles. However, there are several major political and institutional obstacles to implementing effective controls:

- There is not existing authority to regulate privately owned parking facilities.

- There is a lack of regional authority to establish uniformity and insure equity in implementing controls.

- There is a concern for maintaining a high level of access to community activities.

It is apparent that without major changes in the existing institutional make-up in the State and region, the implementation and enforcement of parking control measures will be left to the individual cities and counties. While the regional agencies can provide encouragement and support in developing Parking Management Plans, the actual "plan" preparation should be left to the individual cities in order to maximize the probability of success and to broaden the base for decision making.

Current Status of Transportation Controls

The following documents a set of transportation control projects currently operating in the San Francisco Bay Area. Some were required as elements of the TCP, while others are the result of agency transportation planning.

1. Ramp and Mainline Metering:

I-580 - Beaumont Avenue east bound on-ramp in Oakland;

I-280 - 5 north bound on-ramps between Winchester Road and Route 85 in San Jose. Wolfe Road on-ramp provides by-pass for buses and carpools of 2 or more. Average speed during peak increased from 20+ to approximately 40 mph;

Rt 101 5 north bound on-ramps between Capitol Ave. and Route 17 in Santa Clara County;

Rt 17 Presently under construction; 23 north bound and south bound on-ramps between Route 9 and Route 101 in Santa Clara County;

Bay Bridge: In March 1974, an overhead metering system was installed just beyond the toll plaza at a cost of $350,000. This system has maximized the operational efficiency of the bridge.

The following two projects are scheduled to be advertised in May 1977:

Rt 101 5 north bound on-ramps between Route 17 and Fair Oaks Blvd. in Santa Clara County;

Rt 101 Upgrade five north bound on-ramps between Capitol Ave. and Rt. 17.

2. <u>Preferential Bus/Carpool Lanes on Freeways</u>:

Rt 101 Marin County Exclusive Bus Lanes. In 1972, a 3.9 mile northbound contra-flow exclusive bus lane was opened just north of the Golden Gate Bridge for use during the period 4 to 7 p.m. The contra flow land costs about $5000/month for setup. Approximately 100 buses use the lane, carrying about 4500 persons. In 1974 the project was extended northerly an additional 3.8 miles when with-flow bus lanes were opened in both directions. Carpools were later allowed to use these lanes. Vehicles using these lanes save approximately 6 minutes in the a.m. peak and 3 minutes in the p.m. peak.

Rt 280 In October 1975, a two mile bus/carpool lane was opened on southbound I-280 in San Francisco from Sixth Street to approximately one-half mile south of Army Street. Approximately 200 carpools and 12 buses use this lane during the evening peak. These vehicles save from 3-1/2 to 5 minutes.

S.F. In San Francisco bus lanes are in operation on Post and Sutter Streets between Van Ness and Taylor. Approximately 60 buses use these lanes during the peak periods. Muni has reported improved schedule adherence, (but no over-all decrease in travel time.) A bus lane will open this month along Mission Street.

3. <u>Toll Incentives</u>:

Bay Bridge - In December, 1971, with-flow carpool and bus lanes were opened at the westbound approach of the toll plaza. In 1975 carpool tools were eliminated. During the 6 a.m. - 9 a.m. peak period, 430 buses and 2,200 carpools use the priority lane, saving up to 5 minutes each trip.

San Mateo-Hayward and Dumbarton Bridges - Toll free preferential lanes for buses and carpools were opened on both these bridges. Approximately 520 carpools and 40 buses use these lanes during commute periods.

Golden Gate Bridge - The Golden Gate Bridge District began allowing carpools to use the bridge toll-free in 1976. Approximately 1100 carpools use this lane.

Toll Revenues - AB664 gave MTC authority over the level and use of tolls on the trans-Bay bridges. MTC has recently proposed raising the tolls and using the excess revenue for transit.

4. Carpool Matching Program:

RIDES - is a program operated by Caltrans District 04 to promote carpooling in the San Francisco Bay Area. The program started in 1973. There are currently 25,000 persons on file. A survey conducted in 1975 indicated that approximately 5000 persons had formed carpools as a result of the program. The program has a budget of $261,000 for this year.

5. Improvement of Transit Service:

AC/BART - Coordinated Fare - The AC/BART transfer system provides for free transfers from BART to AC.

MUNI/BART Coordinated Fare - The MUNI/BART transfer system provides two tickets for MUNI bus rides for 25¢, a savings of one-half the full regular fare.

Santa Clara - Santa Clara Transit District was formed in 1972. Operations commenced in 1975 with 233 buses. Frequency of service ranges from 5 minutes to one hour. Several passes are available: $10 for unlimited travel for one month, $4 for one month unlimited travel for youth, senior citizens and the handicapped. The District also operated 9 buses for "Commute Specials" - these are used by some of the corporations. Fares range from 40¢ to $1.00.

Bus Pre-emption - A bus pre-emption system is to be installed along a portion of Almaden Expressway. Twelve signalized intersections are involved. The traffic signal equipment is under construction.

San Mateo County - San Mateo Transit District was formed in 1974 and operations commenced in July 1976. Two hundred buses provide service to and within most cities in San Mateo County including a connecting service between the Daly City BART station and San Francisco Airport. Buses also serve Southern Pacific Stations in the county. Buses operate approximately 15 to 30 minutes apart during commute hours and 30 to 60 minutes apart at other times. The basic fare is 25¢ with a 10¢ charge for additional zones.

Marin County - In 1970 Golden Gate Transit introduced a new ferry service between Sausalito and San Francisco. Additional service was added in December 1976 between Larkspur and San Francisco. Two additional ferries are to go into service this year.

Napa County - Napa County introduced a Dial-A-Ride system which is designed to provide local transit service in three communities: St. Helena, Calistoga and Napa. The service is provided using one bus.

Sonoma - One mini-bus operates in Sebastopol. Transit service in Santa Rosa is provided by 13 buses, which operate approximately 40 minutes apart.

Solano - In August 1975 the City of Fairfield implemented a Dial-A-Ride program using 5 vans. The service area is seven square miles with a population of 40,000. Fares are 50¢ regular and 25¢ for senior citizens and handicapped. Total ridership for August 1975 to April 1976 was 64,086 with a daily average of 243 passengers.

AC Transit - AC Transit now provides contract city services in Concord, Pleasant Hill, and Moraga/Orinda. AC Transit also connects with Santa Clara County Transit District buses at Fremont BART station.

BART Feeder Express - BART Express Buses connect outlying East Bay communities with BART: Alamo, Danville, Dublin and San Ramon to Walnut Creek Station; Dublin, Pleasant Hill and Livermore to Hayward and Bayfair stations; Pleasant Hill, Martinez, Pittsburg, Antioch, Oakley and Brentwood to Concord Station; and Pinole to El Cerrito Del Norte Station. Buses run from 10 to 20 minutes apart during commute hours and approximately hourly at other times. Fares are 25¢ per zone (50¢ maximum).

6. Preferential Parking:

San Francisco - Caltrans is in the process of leasing 4 state parking lots for carpool use. There would be 580 stalls available, open only to carpools of 3 or more. The fee would be not more than $10/month.

Conclusions

The development of the AQMP can benefit from the experience of the earlier plans.

First, the Plan must be realistic in terms of what it can achieve. The AQMP is already oriented this way. It is not designed to achieve the standards by a specific date, but instead will evaluate the impacts of different strategies so that a decision can be made on a time schedule which results in attainment and maintenance of standards "as expeditiously as practicable".

Secondly, the Plan should be specific with respect to the extent, location, and implementation of controls. Measures which are described in broad or general terms will have little chance of implementation. On the other hand, a Plan which includes detailed procedures for implementation will be most likely to succeed.

The process of developing the Plan must include the potential implementors. Again, the AQMP is following this through the broad representation on the Environmental Management Task Force, the Technical Advisory Committee which is guiding the development of the AQMP, and the Joint Technical Staff which is developing the Plan. Further efforts will be made to bring in the transit operators and other local implementors as necessary.

Initially the experience with the implemented strategies is also valuable. The carpool incentives seem to be successful. The transit additions were also rather significant, but the problems of financing are becoming critical. Despite these incentives, auto travel has not really decreased. This would indicate that some combination of auto restraints and transit/carpool incentives is needed. This appears to be the most promising direction for the AQMP.

LAND USE CONTROLS

Last among the control measures to be considered are the so-called "land use controls". This term as traditionally used is a misnomer since measures dealing with land use, or land development, include a wide array of non-regulatory devices from the general plan of cities and counties to the service commitments of special districts. The more current and more widely used term "growth management" also means many different things in many different jurisdictions. Hence, in the ABAG Environmental Management Plan we use the terms "development policy" or "development strategy" to signify the land development objective sought, and the term "policy instruments" to mean the measure or tools of implementation.

Land development policy instruments are documented as a separate category due to their unique nature and role in air pollution control. Four points of reference illustrate their unique status as compared to the other major categories previously described:

1. The relationship of land development policy to air pollution control has not been clearly defined. The policy instruments now in effect in most jurisdictions were adopted to accomplish other planning objectives - though they may secondarily accomplish air quality related objectives such as minimizing trip lengths, minimizing the need for automotive travel, and maximizing the use of non-automotive modes of travel. The most universally used development policy instrument, such as zoning, long pre-date air quality concerns and have rarely been adopted with air quality concerns as specific objectives. The newer instruments, such as building permit controls over time, are proliferating rapidly, but again primarily for non-air quality objectives such as fiscal management of urban services. The newer types of instruments are untested, either technically or legally, as to their potential effect on regional air quality.

2. <u>The inter-governmental complexities of land development policy instruments make their testing and implementation more difficult</u>. The bulk of day-to-day land development decisions are made by an ever increasing list of local units of government. The basic aspects of regionwide land development: how much development occurs where and when, and what type of development it is to be, at what densities, are determined incrementally by hundreds of units of local government in the Bay Region. The aggregate of land development decisions from the most local level up to the total region involves not only the nine counties and 93 cities - as presently constituted - but also involves a significant number of independent special purpose service districts.

3. <u>There is no regional authority over land development to establish uniformity and deal with regionwide equity</u>. The extremely local nature and tradition of land use controls makes them notoriously subject to "spot implementation" in some subregional locations. This can obviously result in the transfer of the "growth problem" and its concomitant air quality problem to another location within the region.

   The state has intervened significantly in the last ten years to directly control development in terms of two critical state resources: The San Francisco/San Pablo Bay and the ocean coastline. However, the geographic jurisdictions of the Bay Conservation & Development Commission and the regional coastal conservation commissions are still relatively localized.

   Even at county level countywide authority barely exists. It exists primarily as inter-jurisdictional coordinative measures more than authority over land use regulations. The county Local Agency Formation Commissions (LAFCO) are the most significant and their role is primarily one of deciding which jurisdiction will apply its policy instruments where (and when) but still without specific countywide authority over the land use regulations themselves.

4. <u>The time period for achieving significant change in the aspects of land development that affect air quality varies considerably</u>. The newer policy instruments, which are frequently keyed to the timing of developments such as permit allocation systems can have significant effect in the short term. However, as indicated above, they are relatively untried. The older more universal development policy instruments, such as zoning and provision of essential services, are effective primarily in the long term - beyond 10 years and in many cases beyond 20 years.

<u>Land Development Policy As Currently Carried Out in the Bay Region</u>

The implementation of land development policy includes the wide array of things local governments are doing to accommodate the growth as they individually foresee it. The development policy in each locality is a function of what local governments -- cities, counties, and service

districts -- are doing with their legal and fiscal tools to regulate or manage land development as well as support development with essential urban services such as sewers, water, and roads. Information on the current operating policies of local service providing and regulatory agencies was inventoried in ABAG's 1976 Local Development Policy Survey.[1]

Development policy in local jurisdictions in the Bay Region has come to mean much more than the general plans of cities or counties. The general plans and their zoning counterparts have been supplemented by capital improvement programs, special tax programs (e.g., Williamson Act Agricultural Preserves), specialized regulations in hazardous areas (e.g., slope and flood area regulations), building permit allocation programs, and many more devices. In some cases cooperative programs are in effect among cities, counties, and special districts to apply their individual policy instruments jointly so as to accomplish common development and service objectives.

1) ABAG Series 3 Projections of Population, Employment and Land Use

ABAG has utilized this inventory of local development policy as a basic ingredient in its Series 3 Projections of population, housing, employment, and land uses.[2] The Series 3 projections represent the probable short term and long term outcome of the assumption that current local land development policy will continue essentially unchanged for the period 1970 to 2000.

The Series 3 Projections account specifically for a wide array of local growth management programs. This was accomplished by means of a three phase survey done jointly by ABAG and the nine Bay Region counties:

- A mailback survey questionnaire to sound out the kind of growth management program now in effect in each locality and the policy instruments used to implement it;
- Followup in-depth interviews of the most critical agencies in each locality;
- Translation of the policy information into the projection system. This included "workshop" reviews with interested local agencies on how the policy information was handled and the resulting projections.

The Series 3 Projections will be utilized to assess air quality implications of current local land development policy.

2) The Mailback Questionnaire on Local Development Policy

The ABAG 1976 Local Development Policy Survey contacted almost 400 local agencies including about 200 city agencies, 73 county agencies, and 125 independent special districts. Seventy-seven of the Bay Region's 93 cities responded along with 52 county agencies and 59 independent special districts. The results from the mailback questionnaire were used to identify the key policies and policy instruments for in-depth examination in subsequent interviews.

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1 The methods and results of the ABAG 1976 Local Development Survey are summarized in this report. A subsequent ABAG report will provide greater detail on local development policy.

2 See Summary Report, Provisional Series 3 Projections, March 2, 1977, ABAG.

The following table summarizes the results of the questionnaire survey in terms of policy instruments now in use to support development, constrain development, or both. On the basis of number of jurisdictions using them, without regard to the size of the jurisdictions the following general conclusions are noted:

a) Among Development Supporting instruments, assessment districts, redevelopment programs, and capital improvement programs for transportation, sewer, and water systems are the most common. Redevelopment incentives such as tax incentives or other special land reserves with service commitments are relatively rare but do exist as precedents for more widespread application in the region.

b) Among Development Constraining instruments open space zoning (and easements), public land acquisition, sewer connection limits and zoning moratoria are most prevalent; with transportation access limits, building permit moratoria, and prime agricultural land preserves of secondary importance, numerically.

c) In the category of instruments that can be used to constrain or support development, the LAFCO spheres of influence dominate.

SUMMARY OF
LAND DEVELOPMENT POLICY INSTRUMENTS IN EFFECT
BAY REGION 1975

Land Development Policy Instruments (In rank order by frequency regionwide within group)	Number of Jurisdictions Using			
	Total Active	Prior to 1970	1970 to 1975	Expect by 1977
Group 1 Supporting Development				
Assessment (Improvement) Districts	34	30	4	1
Public Assisted Housing Programs	25	12	13	2
Redevelopment Programs	15	7	8	8
Transportation Extension C.I.P.	21	16	5	4
Sewer Extension Capital Improvement Program	14	10	4	5
Public Housing Programs	9	6	3	1
Water Extension Capital Improvement Program	8	8	0	1
Low Income Housing Program	8	3	5	6
Special Service Commitments	6	5	1	2
Sale of Public Land	6	5	1	0
Industrial/Commercial Land Reserve (other than zoning)	0	0	0	3
Group 2 Neutral or Mixed (used to support or constrain Development)				
City Spheres of Influence (by LAFCO)	39	12	27	0
Development Fees	37	27	10	1
User Charges	32	27	5	0
Cluster Zoning	28	21	7	3
Slope/Density Zoning	21	6	15	6
Plan Conformance Re-zoning	19	1	18	14
Mass "Up" or "Down" Zoning	11	1	10	8
Development Rights-Purchase or Transfer	8	5	3	4
Land Banking	3	-	3	2
Development Sequence Zoning	4	4	0	4
"Floating Zones"	3	3	0	3
Group 3 Constraining Development				
Open Space Zoning	26	5	21	8
Open Space Easements	23	5	18	4
Zoning Moratorium	18	8	10	5
Sewer Connection Limits	20	9	11	3
Land Acquisition for Public Use	20	12	8	1
Prime Agricultural Land Preserves	11	5	6	1
Building Permit Moratorium	11	0	11	0
Watershed Protection Program	13	8	5	1
Transportation Access Limits	12	7	5	2
Water Connection Limits	7	4	3	3
Other Utility Connection Moratorium	7	7	0	0

Source: Preliminary tabulations ABAG Local Policy Survey, 8/15/76. 65 cities reported of 76 responding. Special districts not included.

3) The Local Development Policy Interviews

ABAG contracted with an agency in each county to conduct in-depth interviews of appropriate county agencies, all city planning departments, and a few selected special districts. The interviews focused on specific subject areas to document how that agency's policy actions would affect the timing, quantity, location, density, and type of land development. The subject areas covered included recent development history, committed land development, proposed land use and zoning, current service constraints and committed improvements, and special problems including certain environmental hazards.[3] Air Quality was not cited as a specific objective in the interviews.

4) Translation of the Local Development Policies Into The Series 3 Projections of Population, Employment and Land Use

ABAG staff and the counties jointly translated the policy information into the projection system. A set of guidelines were established as a means of sorting through the array of policy information in each locality. The guidelines were used to interpret and summarize the detailed policy information into a few consistent categories of "development potential" which could be represented in the projection system. The guidelines emphasized the role of county LAFCO's in designating areas of likely urbanization. They also defined development potential in terms of specific commitments for sewer, water, and roads, as well as specific land development regulations concerning flood hazards, slopes, density, etc. Potential for industrial development was based on both the local development policy information and on a previous regionwide inventory of industrial land.[4]

The table below summarizes the quantities of land in each policy-related category in each county. This policy-related land data was derived at census tract level (1,042 census tracts in the nine Bay Region counties) and summarized to 440 regional "zones" for the projection system.

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[3] For more detail see the subsequent ABAG report on the 1976 Local Development Policy Survey.

[4] In 1975, ABAG cooperated with the Bay Area Pollution Control District to conduct a Vacant Industrial Lands Inventory.

Implications of Regional Growth on Current Development Policy

The implications of regional growth on current development policy are documented at length in the ABAG report on the Series 3 Projections. In summary, development policies concerning industrial growth are out of balance with those related to residential growth. Industrial land reserves far exceed the projected need to 1990. Residential land reserves based on service commitments and regulation are insufficient for the apparent need beyond 1990, assuming the highest probable regional growth trend; and insufficient in some areas even assuming the lowest probable regional growth trend.

These implications begin to indicate the importance of development timing and possible timing controls to the context of possible regional alternatives for air quality assessment.

Alternative Land Development Configurations For Air Quality Assessment

The ABAG Series 3 Projections of Population, Employment and Land Use constitute one assumption about land development for air quality assessment - essentially assuming that current land development policy will remain unchanged over both the short term period to 1985 and also the longer term period from 1985 to 2000.

Alternative configurations to this current policy/trend will need to be structured based on the findings of that assessment. The conceptual structure for such alternatives can and should be set before those findings are complete. They must be realistic in two ways:

- They should be realistic alternatives that speak directly to the potential impact meeting air quality standards may have on the region's economic and social need for development, and to the potential impact that achieving social and economic objective may have on air quality;

- They should be realistic alternatives based on clear and documentable assumptions about what agencies would use what policy tools to carry them out, and when.

Thus the alternatives must be "can-do" alternatives not "eye in the sky" concepts of idealistic urban growth patterns.

Environmental/Developmental Impacts can be conceptually anticipated by structuring "best case" and "worst case" extremes which on one hand assume air quality objectives will be achieved in the ten year short term time period (by 1985) and on the other hand assumes they will not be met perhaps even in twenty years. In general, the air quality "best case" is presumably one that constrains growth especially in the

short term time frame - this might be considered by some to be the "worst case" for achievement of social/economic objectives. Conversely, the air quality "worst case" of delayed air quality objectives may constitute an alternative that largely accommodates the growth trend through the short and long time frame - possibly the "best case" for social/economic objectives.

With this concept, the extreme outside alternatives become either two or four in number depending upon whether you wish to focus on the short term time period somewhat separately from the longer term time period:

	Short Term 1975-1985	Long Term 1985-2000
Constrain Growth	X	...
Accommodate Growth	...	X

Policy Assumptions can be structured around those key aspects of land development that can be related both to specific jurisdictions with specific policy instruments, and to specific ways ABAG's analytic "land use" models can represent the alternatives for purposes of testing and assessment. Those aspects are the timing, quantity, location, density, and type of land development.

In the current policy framework the aspects of development can be ranked with respect to the degree that they are presently dealt with from the most local level up to the regional level.

> Timing of development is currently reflected in only a very few local development policies. It may become the most important regional aspect of development in the alternatives, in treating the assumptions of when the air quality standards will be met.
>
> Quantity of development is currently reflected in a few development policies. Those having the most effect are keyed to service capacities of existing and committed sewer systems. Quantitative controls, together with timing, may become much more important at the regional scale for air quality objectives than it currently is for local development and service objectives.
>
> Location of development is currently dealt with most effectively at the county level by the Local Agency Formation Commission (LAFCOs). The current regional trend continues to focus development southward, but alternatives may need to assess the hows and whys of encouraging more development in the north bay counties.
>
> Density of development is currently an exclusively local concern. The current regionwide aggregate of local policy is notably for much lower densities than have occured historically. A more consistent regionwide focus on density related to air quality concerns will need to supplement the likely parallel focus on higher density options as related to better urban services, most notably transit service and feasibility.

Type of development has also been an exclusively local prerogative dealt with primarily through zoning. Issues related to the balance of housing and jobs are currently surfacing in terms of local tax revenues and service costs. The regional implication to air quality, especially via the number and length of automobile trips will likely be one of the dominant findings in the assessment of current development policy regionwide. Sensitive as it may be, some regional role with respect to type of development should be examined in alternative land development scenarios.

One further essential item to be considered in the structuring of alternatives covers those departures from current local policy that are already under consideration in many jurisdictions. Massive changes in density regulations, and new policy frameworks keyed to the timing of development (ala Petaluma) and housing/industrial balance for fiscal objectives are but two of many that are already significant.

In the current policy/trend assumptions of the Series 3 Projections there is considerable variance in which of the five development aspects are effectively dealt with in different jurisdictions. For example, Petaluma is one of the very few jurisdictions that deals specifically with timing and quantity of development with its now famous growth management program, as well as dealing more traditionally with location, type and density through its zoning laws. Many more traditional jurisdictions deal specifically only with the latter.

In the alternatives much attention will need to be given to combinations of jurisdictions and policy tools potentially dealing with more of the development aspects. Also, more jurisdictions will be interested in This may involve institutional structures similar to those already in effect in Santa Clara County among the county and its cities. It could also involve the assumption of a greater role in aspects of local development by state or regional bodies.

Examples of land development alternatives addressing air quality and other regional concerns will be described in subsequent reports and memoranda.

AQMP/Tech Memo 5 * April 1977

CANDIDATE CONTROL MEASURES**

Air quality improvements can be achieved in a variety of ways. To date, many stationary and mobile source controls have been implemented. Similarly some transportation and development controls have been instituted. This technical memorandum presents a listing of additional control measures which might be considered for further air quality improvements. It also describes the process used for screening the many proposals and the results of this preliminary screening. The screening process has resulted in a list of control measures proposed for more detailed analysis and possible inclusion in alternative control strategies for testing. Separate sections of this memo deal with stationary source controls, mobile source emission controls, transportation controls, and land use (or development) controls.

INTRODUCTION

This memo builds on AQMP/ Tech Memo 4, "Status of Existing Controls Related to Air Pollution." Tech Memo 4 described control measures in existence for stationary, mobile and land use sources. These control measures in use range from hardware controls developed over the years for industrial plants and vehicles, to regulations such as zoning for land use. It pointed out that the land use measures were generally developed for general planning reasons rather than air quality needs.

Proposed control measures for this study were developed by the members of the AQMP-Joint Technical Staff with assistance from the AQMP-Advisory

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*Assistance provided by Environmental Planning Branch, District 4, CALTRANS.

**"Control measure" and "control tactic" are used synonymously to describe an individual proposal, e.g.,inspection and maintenance. "Control strategy" is used to describe a combination of two or more control measures, e.g., improved transit service, carpooling program and parking surcharges.

Committee. Initial lists of control measures were developed by the agency with appropriate expertise. For transportation control measures it was the Metropolitan Transportation Commission for mobile source emission controls--California Air Resources Board, for stationary source control measures--Bay Area Air Pollution Control District, and for land use measures, it was the Association of Bay Area Governments. These initial "shopping lists" of measures were presented to the AQMP Joint Technical Staff for review and comment. The complete set of control measures was reviewed at meetings of the AQMP-Joint Technical Staff and additional input was obtained through discussion panels set up at the March 17, 1977 meeting of the AQMP-Advisory Committee.

The "shopping lists" were then screened by the originating agencies to determine feasibility. This screening resulted in a shorter list of measures proposed for further analysis based primarily on technical effectiveness. If a measure was judged to have good potential for reducing pollution, it was retained despite any perceptions of high cost or implementation difficulties. This shorter list will be analyzed for the full range of environmental impacts. This impact analysis will accompany recommended scenarios to the Environmental Management Task Force where review, discussion and decisions on any tradeoffs will take place. Documentation of the analysis conducted for the screened list of control measures and strategies will be published in a separate technical memorandum.

Comparability of Analysis

Information concerning candidate air pollution control measures is a function of readily available data in the literature or the experience of the agencies and committee members involved. For example, considerable work has been done on transportation controls and mobile source emissions hardware. The experience and knowledge with stationary source controls is similar. On the other hand, little work has been done using land use controls to improve air quality.

Therefore, the screening analysis at this point lacks quantification or an indication of effectiveness for most measures. In the next phase of the AQMP-Joint Technical Staff work considerable effort will be devoted to assessing the emissions and air quality impact of the proposals. Again, details of this analysis and the procedures used to analyze alternative control strategies will be documented in a subsequent technical memorandum.

STATIONARY SOURCE CONTROL MEASURES

An initial list of thirty-seven control options was developed by the BAAPCD ranging from new source review to tighter restrictions on existing emission

sources. Many of the options were closely-related duplicates or would have such little impact on emissions that only twelve measures appeared to be reasonably effective and recommended for additional consideration. The twelve measures are listed below with a brief description of each:

1) Use of High Solids and Water Based Surface Coatings. This has been considered for sometime and may be a feature of the organic solvent regulation being developed by the ARB. In one form such a rule would give the control agency authority to specify industry by industry the type of coating to be employed.

2) Closed System Organic Storage. This measure would require storage of organic chemicals or fuels, probably defined by vapor pressure, to be in a closed system with vapor recovery or use as fuel. This requirement would mean expensive conversion or replacement of existing tankage, and application to new construction.

3) Limiting Maximum SO_2 Concentration in Emissions. Present limit is 6000 ppm affecting a few industries such as sulfur recovery and acid plants. A limit of 300 ppm has been considered and is achievable with available technology.

4) Fuel Conversion. Limit Sulfur Content of Fuel to 0.25%: This regulation would attempt to ameliorate build up of SO_2 emissions due to expected conversion from natural gas to oil or coal fuel. The current emission limitation of 300 ppm SO_2 corresponds to use of 0.5% S fuel. 0.25% sulfur fuel will be expensive and in short supply; its use has been mandated for the South Coast Basin by the ARB, effective in 1981.

5) Best Available Control Technology on New and Existing Sources. This could be two separate measures, new and existing. For new large installations it is virtually de facto in effect. To apply this measure to existing emission sources could be very expensive. A BACT regulation could supplant many other forms of regulatory control; it is itself virtually required by some very tight emission limits. BACT has several problems - how to define BACT and how much authority to give a control agency in specifying equipment to be used among others. A BACT rule has been under study for sometime.

6) New Source Review With or Without Off-Set. There is currently in effect a very strict Bay Area Air Pollution Control District new source review regulation as required by the EPA nad ARB. The problem is not one of imposing a rule, but of modifying the rule to allow economic and industrial growth and to obtain modernization of the area's industrial plant while still reducing air pollution.

7) Lower Reid Vapor Pressure of Motor Gasoline. A lower vapor pressure would mean less evaporative emission of gasoline from storage, handling, and vehicles. Side effects are less certain.

8) NO_x Control for Off-Highway Construction and Agricultural Equipment. The significance of this measure is uncertain and it should probably be tied to heavy duty motor vehicle control.

9) NO_x Limits for All New Boilers. Large boilers or furnaces are already subject to limitations. The BAAPCD has been studying limitations on smaller boilers but information as to reductions achievable on these smaller units is sparse.

The actual effect of No. 8 and No. 9 is questionable. The relatively few excesses of the NO_2 standard have been motor vehicle related and the effect on the photochemical process is uncertain.

10) & 11) The BAAPCD already imposes strict regulations on grain loading and visible emissions. Particulate emission concentration limits could be set lower and process weight allowances could be reduced but with somewhat uncertain results. Process weight regulations apply to few but large industrial plants. This might also be covered under BACT.

12) Plant Operation Scheduling. This proposal envisions scheduling operations of the areawide industrial and commercial establishment so as to level out, over the day, peaks of transportation and industrial emissions. The effect would not necessarily be to reduce overall emission of pollutants, but to level off the peaks which constitute excess of air quality standards. Implementation, however, would cause extensive changes in work and social patterns. If made voluntary it would be ineffective; if imposed it would place vast and possibly unacceptable authority in some control agency.

Table 1 provides a summary of relevant information on the screened list of stationary source controls. Much of the data presented are preliminary estimates which will be analyzed in more detail as the control strategies are developed.

The entire initial "shopping list" of measures is presented in Table 2. Measures not included in Table 1 were judged by the BAAPCD staff not to be as effective in improving air quality. In each list, particularly in Table 2, there are shown individually items which may only be variations of others, or which would be included in or preempted by others. For example, a Best Available Control Technology requirement might include many other forms of regulation. Thus further selectivity and careful development of any actual regulation imposed is indicated.

TABLE 1. PRELIMINARY SCREENING OF STATIONARY SOURCE CONTROL MEASURES

STRATEGY	No. of Categories of Industry Affected	Contaminant	No. of Industrial Sources Affected	Source Inventory Emissions Tons/Day			Degree of Technical Availability	Emission Reduction Achieved (T/D)		Degree of Impact of Reduction on Air Quality in Bay Area
				1975	1985	2000		1985	2000	
1/ **High Solid & Water Base Coatings**	10	O	500	150	140	170	Fair	60	70	Good
2/ **Closed System** Organic Storage	10	O	1,000	60	70	80	Good	40	50	Fair
3/ **Limit Max SO_2 to** 300 ppm or Equiv. Mass	2	S	10	80	90	105	Good	40	50	Fair
4/ Fuel Conversion A) **Limit at 0.25%S** B) Control Equip.	30 3 3 3	S P S N	1,000 40 40 60	34 10 34 32	220 20 220 306	220 29 220 252	Fair Poor Poor Poor	100 10 100 150	100 10 100 100	Excellent Negligible Excellent Fair
5/ BACT on New and Exist. Sources	100	P O N S C	10,000	117 530 268 199 412	150 570 420 410 480	165 758 406 380 578	Fair Good Poor Fair Poor	50 200 100 250 150	55 300 100 250 200	Good Excellent Fair Excellent None
6/ Continue NSR with Some Sort of Trade Off	30/YR	All	400/Year	?	?	?	Fair	?	?	Good for Interim 10 Years
7/ Lower Reid Vapor Pressure of Motor Vehicle Gasoline ~3 PSIA	100	O	**6 Refin. 60 Bulk Plt. 6000 Ser.St. 3.5 M Veh.**	105	75	80	Fair	30	35	Fair
8/ NO_x Control for Off-Highway Equipment	-	N	-	45	50	60	Fair	30	40	Low
9/ NO_x Limits for all new boilers	-	N	-	-	-	-	?			Currently under Study--- Low
10/ Lower Particulate Emission Grain Loading Limit							Fair			Low
11/ Tighten Process Weight Regulation							Poor			Low
12/ Plant Operation Scheduling	0		10,000	-	-	-	Poor	0	0	Infrequent

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TABLE 2 - SUGGESTED STATIONARY SOURCE CONTROLS

OPTIONS	ORGANICS	NO_x	PART.	SO_2	COMMENT - NOTE: *INDICATES THE OPTION OMITTED FROM TABLE A
1. Require high solids surface coatings wherever practical.	X				Coating will put out about 140 T/Day from total of 570 T/Day organics in 1985. With new developments substantial reductions in this area can be achieved. Requiring high solid coatings and water base coatings as they are developed will reduce organics. Again by requiring control equipment on this equipment irrespective of complying solvent will further reduce organic emissions.
2. Require water base coatings wherever practical.	X				
3. Adopt ARB Standards for organic liquid storage floating roof tanks.	X				* May be forced by State.
4. Adopt closed system organic liquid storage with vapor recovery or use as fuel.	X				Closed system vapor controls will be expensive but effective.
5. Require vapor recovery on smaller solvent users -- dry cleaners, degreasers, etc.	X				* In 1985 the emissions from this operation will be about 75 T/Day, but requiring controls will probably close businesses. Could come under BACT rule.
6. Adopt organic regulation now being developed by ARB -- ORGSOL.	X				* The general ORGSOL concept is not yet defined. May be forced by State. Items 1 & 2 probably a main element.
7. Enact new maximum SO_2 emission concentration limit 300 ppm or other.				X	This is important in SO_2 reduction. Reduction in the order of 35 T/Day can be achieved by adapting concentration limits around 300 ppm.
8. Reduce fuel sulfur content, to 0.25% or other concentration.				X	Appears to be technically and economically impossible in the short term. Will probably be done over longer period.
9. Adopt NO_x controls for non-highway and construction equipment employing internal combustion engines.		X			This probably has little benefit on Air Quality. Excesses of standard have been automobile related.
10. Adopt NO_x limits for all new boilers.		X			Very long term. Large boilers already regulated.
11. Adopt lower particulate grain loading .10, .05 grain/cu. ft.			X		Looks to be an expensive tool for the amount of reduction. BACT could cover.
12. Lower process weight allowable scale.			X		* Expensive on the present equipment for the amount of reduction. Not many would be affected. BACT could cover.
13. Lower process weight maximum allowable.			X		* Expensive on the present equipment for the amount of reduction. Not many would be affected. BACT could cover.

OPTIONS	ORGA-NICS	NO_x	PART.	SO_2	COMMENT - NOTE:
14. Adopt BACT regulation for existing sources with time scale for compliance.	X	X	X	X	BACT on existing facilities, BACT on new facilities seems to be one of the favorites of EPA. It is based on equipment specification rather than performance. An alternative would be to adopt lower limits for NSPS which would represent BACT. (14-17)
15. Adopt BACT for all sources in lieu of emission concentration limits.	X	X	X	X	
16. Adopt BACT for all sources in addition to emission concentration limits.	X	X	X	X	
17. Adopt a modern process technology rule aimed at promoting modernization of the area wide plant. Might for instance, suspend a BACT rule for a period of time in return for an agreement to modernize a plant with BACT included in modernized version. This is a hazy idea, not well defined, but something is needed to encourage replacement of old plant with new.					
18. Extension of requirements to smaller operations, i.e. fewer exemptions.	X	X	X	X	* Minor results with maximum disruption.
19. New Source Review - continue present rule.	X	X	X	X	This is "NSR with Trade-Off" favorite of EPA. Will reduce emissions on the long run. As newer plants are built eventually older dirtier plants will be reduced; but if conditions are attached e.g., off-set, they may tend to slow down putting up newer plants. Encourages speculation to holding older dirtier plants for future gain. (19-27)
20. New Source Review - 100% off-set.	X	X	X	X	
21. New Source Review - 110% off-set.	X	X	X	X	
22. New Source Review - sliding scale off-set.	X	X	X	X	
23. 20-21 or 22 with limited area for off-set.	X	X	X	X	
24. 20-21 or 22 with inter-pollutant off-set.	X	X	X	X	
25. 20-21 or 22 with no inter-pollutant off-set or inter-pollutant off-set governed by location, etc.	X	X	X	X	
26. 20-25 qualified so that no credit is allowed for emissions that are in excess of other limitations.	X	X	X	X	
27. 20-25 with arrangement for off-set banking, allowing a prospective new source credit for emission reduction off-set achieved beyond that required by existing regulations.	X	X	X	X	

OPTIONS	ORGANICS	NO_x	PART.	SO_2	COMMENT - NOTE:
28. Institute a comprehensive program to reduce excessive use of energy, by regulation where necessary imposed by the APCD, the Energy Resources Commission, Building Inspection Departments, etc. This can encompass many things, for example: survey of the efficiency of building heating and air conditioning systems, insulation of hot air or water delivery systems, reduction of over illumination, reduction of use of electricity for display purposes, promote use of heat recovery.		X	X	X	* Will reduce emissions but would be primarily fuel conservation measures. Not important for air pollution as long as gaseous fuel is available.
29. Plant operation scheduling: a) Seasonal scheduling to reduce polluting operations during critical weeks or months as determined by meteorology. b) Scheduling maintenance down time and vacations, possibly short downs, to reduce pollutant load at critical times. c) Interruptable operation dependent upon air quality conditions. d) Stagger operations between plants to spread operation over seven days instead of five. Assign plants a 5 day week starting on anyone of the seven days, possibly with some on 4 day 10-hour operation. e) Stagger work hours. For instance, run coating lines only between 4 PM and midnight instead of 7 AM to 3 PM. f) Schedule reduced work days during the smog season with or without longer days during less critical seasons. Rationing the pollution absorbing capacity.	X	X	X	X	Generally difficult due to social-economic factors involved; does not reduce total emissions, but does reduce peaks. This option can be considered in modeling.

OPTIONS	ORGANICS	NO_x	PART.	SO_2	COMMENT - NOTE:
30. Air monitoring combined with meteorological analysis can pinpoint certain air quality problems which might be controlled by one means or another, not necessarily means exercised by the APCD. An example is the frequent heavy concentration of CO built up in an area of San Jose on Friday evenings by the concentrated recreational driving of hotrods during the winter inversions. Another example is an unpaved lot in the Livermore area which happens to be close to a monitoring station. There are others not near a monitor. A concentrated effort could be maintained to spot such situations and to urge their correction by the proper authorities.	X	X	X	X	* Good points to isolate the problem and trying to abate them. Present and future regulations will take care.
31. Adopt particulate regulation based on particle size.			X		* This probably will be done in future anyway.
32. Replace throw-away container with re-usable containers.	X	X	X	X	* Will be controlled due to other agencies' efforts.
33. Burn solid waste near point of generation, to reduce long hauls.	X	X	X	X	* Not practical and does not amount to net reduction due to better control at fewer locations.
34. Apply 1309 with modified trade-off of 1311 and 1311-2 clearly described as an option.	X	X	X	X	Please see 19.
35. Requiring some sort of retrofitting on older plants. Apply BACT to newer plants through permit system.	X	X	X	X	Will reduce emissions and at the same time allow normal growth.
36. Penalty charge or tax based on amount of emission to encourage reduction.	X	X	X	X	* Open to charge that large companies can buy emission allowance.
37. Lowering the reid vapor pressure of gasoline to reduce hydrocarbon emissions from storage, handling and use of motor vehicle grade gasoline.	X				

Several points become clear in looking over the two lists. First, none of the proposals are new and previously unknown. All have been considered at one time or another; many are already in effect to a degree in the current control program; and most would represent only an increment of pollution reduction over that currently being achieved. Some of these measures are under serious consideration and will likely be adopted whether or not there is an AQMP. Stationary source control is already at the point where spectacular pollution reductions, easily obtainable, are unlikely; but the air quality standards still require further pollution reduction.

MOBILE SOURCE EMISSION CONTROL MEASURES

The emission control measures presented here emphasize reducing mobile emissions through better technology. The California Air Resources Board (CARB) has traditionally exercised its prerogative to adopt and enforce vehicle emission standards more stringent than those required at the federal level. A summary of CARB's program was presented in AQMP/Tech Memo 4. The inclusion of these measures into the AQMP will provide local support for the CARB's existing policy.

The initial list of technical control measures included four measures which are not included here. Two of these measures--promoting the use of new or modified fuels and promoting the use of alternative power sources--were excluded because the AQMP-Joint Technical Staff felt that these two measures would come about as a result of more stringent emission standards and were, therefore, repetitive. The other two--more stringent certification of compliance procedures and a more comprehensive new and used vehicle surveillance program--were combined with the inspection maintenance program described below.

More Stringent Exhaust Emission Controls

Carbon monoxide (CO), oxides of nitrogen (NO_x), hydrocarbons (HC), lead, particulate matter and some sulfur compounds are emitted from automobile engine combustion processes and are expelled into the atmosphere through the exhaust pipe.

The Clean Air Act Amendments of 1970 set as an ultimate goal for light duty vehicles (LDV) reduction of HC emissions by 95%, CO emissions by 96% and NO_x emissions by 89% by 1977. These standards have been delayed already and will most likely be delayed further by Congress. This measure would provide AQMP support for the CARB adoption of exhaust emission standards which reflect the lowest emission levels technically and economically feasible.

Current CARB standards promulgated for 1980 LDV will reduce emissions by 95% for HC, 89% for CO and 72% for NO_x over uncontrolled vehicles. As

further reductions from LDV's become limited, additional controls on medium duty vehicles (MDV), heavy duty vehicles (HDV), and motorcycles may become more important and cost-effective.

More Stringent Evaporative Emission Controls

Evaporative emissions from the fuel system result from daily ambient atmospheric temperature variations and higher fuel temperature after vehicle usage. The CARB has recently adopted an evaporative emission standard of 2 grams per test for 1980 and subsequent model year vehicles. It has been estimated that this standard will reduce the total motor vehicle hydrocarbons by 36% and the HC emissions from all sources by 10% in the South Coast Air Basin by 1990.[1] This measure would recommend that a more stringent standard be adopted and that it be applied to other mobile sources.

Establishment of a Retrofit Program

This measure would require the addition of a new item, or the modification or removal of an existing item of equipment on a vehicle to reduce emissions after its initial manufacture.

Retrofit programs become less effective as old pre-controlled vehicles are replaced with vehicles meeting the more stringent emission standards. Thus, this would be considered a short-term measure which would have to be implemented as soon as possible.

An evaporative emissions retrofit program for all vehicles could be most effective in reducing HC emissions since the 2 gm/test standard will not be promulgated until 1980. A catalytic exhaust-treatment device required for post 1971 vehicles able to operate on unleaded gasoline may also be effective if it can be implemented in the near future.

Emission Standards for Other Mobile Sources

This measure would promote the adoption of emission standards for mobile vehicles such as agricultural tractors, construction equipment, ships entering the Bay, locomotives, recreational vehicles and miscellaneous utility engines.

As emissions from other sources are reduced through more stringent controls, the emissions from off-highway mobile sources will become increasingly more important. For example, in the 1975 BAAPCD emissions inventory these sources contributed about 4% of the organic emissions and 8% of the CO emissions. Present projections by the BAAPCD estimate that these sources will contribute approximately 6% of the organics and 22% of the CO by the year 2000. Thus,

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[1] California Air Resources Board, "Public Hearing on Proposed Changes to Regulations Regarding Vehicle Evaporative Emission Standards for 1980 and Subsequent Model Motor Vehicles," Board Book, November 23, 1976.

a 50% reduction in emissions from other mobile sources by 2000 will give a 3% reduction in organics and an 11% reduction in CO.

Motor Vehicle Inspection/Maintenance Program

This measure requires that vehicles be tested periodically to determine HC, CO, and NO_x emissions. Failure to meet the prescribed emission standards would require that the vehicle be repaired and retested. Vehicles may be required to be tested on a mandatory annual basis or randomly at roadside inspection facilities and on change of ownership. This testing program would apply to new and used car dealerships as well as individual transactions to deter maladjustments being made to maximize vehicle performance. Also included here would be a more rigorous certification testing program by the CARB to reduce maintenance requirements of engine components which influence emissions or, where possible, eliminate this maintenance completely.

A pilot motor vehicle inspection program (MVIP) is currently being run in Riverside. The CARB has determined that the MVIP can provide cost-effective emission reductions. It is estimated that reductions over the total vehicle population would be about 9% for HC, 8% for CO and 0.7% for NOX.[2]

TRANSPORTATION CONTROL MEASURES

The initial list of transportation control measures (Table 3) was compiled from a review of earlier air quality plans in this area and elsewhere. The Bay Area plans that were referenced include the original Transportation Control Plan (TCP) and promulgated by the EPA[3], the substitute TCP proposed by MTC,[4] the Parking Management Plan (PMP),[5] and the Transportation System Management Element (TSME).

Three broad strategies to improve air quality were identified: 1) improve traffic operations, 2) reduce automobile use, and 3) encourage alternative modes of travel. Sub-strategies were defined within these, and the actual control measures were then formulated.

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[2]California Air Resources Board, "Status Report on the Mandatory Vehicle Inspection Program," staff report from the Bureau of Automotive Repair, Board Book, February 16, 1977.

[3]Environmental Protection Agency, "California Transportation Control Plan," Federal Register, November 12, 1973.

[4]Metropolitan Transportation Commission, "Proposed Transportation Control Plan for the San Francisco Bay Area Air Quality Control Region," March 1975.

[5]Alan M. Voorhees and Associates, Inc., "San Francisco Bay Area Parking Management Plan Guidelines, Draft Final Report." 1975.
San Francisco Departments of Public Works and City Planning, "Parking in San Francisco," December 1975.

Once the initial list was complete, a review process began to screen the list down to one that would fit the time and budget constraints of the AQMP study. There were two review bodies--the AQMP-Joint Technical Staff, and the AQMP Advisory Committee.

A number of screening criteria were discussed, including public acceptance and socio-economic impacts. However, decisions of this type must be left to policy-makers, and thus the primary criterion that was used was the effectiveness of each measure in improving air quality. In assessing any improvement, it was necessary to determine which pollutants were being affected.

The Bay Area has been designated an air quality maintenance area for three pollutants--oxidants, sulfur oxides, and particulate matter. The latter two are not primarily due to mobile sources, and it was decided to concentrate on oxidant precursors to screen transportation controls. The primary oxidant precursors are hydrocarbons (HC) and nitrogen oxides (NO_x).

Both of these pollutants are speed dependent, with NO_x increasing at higher speeds, and HC decreasing. With more stringent emission standards and the new catalytic controls, however, cold starts and hot soaks have become more important. Thus the number of trips is important, as well as the vehicle miles of travel (VMT); the effectiveness of transportation controls were evaluated in terms of effect on trips and VMT, rather than speed or redistribution of trips throughout the day.

The initial list of controls is summarized in Table 3. The following pages present a brief description of each measure, along with the results of the preliminary evaluation.

I. MEASURES TO IMPROVE TRAFFIC OPERATIONS[6]

A. Improve Traffic Flow

1. Computerized Traffic Control

- Traffic flow would be improved through a system of computerized traffic signals on selected arterial streets.

- This measure was dropped because only very small reductions in oxidant precursors would be achieved through speed improvements, especially considering the small portion of regional

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[6]Bhatt, Kiran V., "What Can We Do About Traffic Congestion? A Pricing Approach," The Urban Institute, February 1975.
Renake and Rosenbloom, "Peak Period Traffic Congestion: Options for Current Programs," National Cooperative Highway Research Program Report 169, Transportation Research Board, 1976

TABLE 3. CANDIDATE AQMP TRANSPORTATION STRATEGIES

I. MEASURES TO IMPROVE TRAFFIC OPERATIONS

A. Improve Traffic Flow

1. Computerized traffic control
2. Ramp Metering *1
3. Traffic engineering improvements
4. Off-street freight loading

B. Reduce peak-period traffic volumes

1. Staggered work hours
2. Four day work week
3. Off-peak freight delivery

II. MEASURES TO REDUCE VEHICLE USE

A. Restrict Vehicle Ownership

1. Additional license fee
2. Regiatration limits

B. Management of Auto Access

1. Better enforcement of parking regulations *2
2. Limit on number of parking spaces *2
3. On-street parking prohibited during peak hours *2
4. Area license *
5. Auto-free zones *
6. Gas rationing *

C. Increase Cost of Auto Use

1. Road pricing
2. Increased parking costs *
3. Increased gas tax *
4. Increased tolls *
5. "Smog charges" *

D. Reduce the Need to Travel

1. Communications substitutes
2. Goods movement consolidation

TABLE 3 (Cont'd). CANDIDATE AQMP TRANSPORTATION STRATEGIES

III.	MEASURES TO ENCOURAGE ALTERNATIVE MODEL OF TRAVEL	
	A. Increase Transit Ridership	
	1. Additional transit service	*
	2. Fare reductions	*
	3. Improved comfort	
	4. Bus and carpool lanes	*
	B. Encourage Pedestrian Mode	*
	C. Encourare Bicycle Mode	*
	D. Encourage Ride Sharing	*
	1. Toll reduction for carpools	*
	2. Preferential parking and carpools	*
	3. Carpool matching information	*
	E. Promote Para-Transit Alternatives	*

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* Selected for further study and analysis
*1 Combined with Bus/Carpool lanes
*2 Combined into overall parking strategy

traffic that would be affected. Also, the improved flow might induce additional travel, which would offset any gains in air quality.

2. Ramp Metering

- Ramp metering is an effective operational tool which can, under appropriate conditions, promote optimum use of a transportation corridor. Its use also tends to improve air quality in two ways; 1) by changing the character of VMT and 2) by providing bus bypass lanes at ramps with queues of traffic and thus a time saving to those using buses, which tends to encourage a modal shift. However, if congestion on a freeway is eliminated, there is the possibility that, in the absence of any other land use or transportation actions, additional long-distance trips could be generated.

- This measure has been combined with the one specifying bus and carpool lanes because of the concern over the possible travel-inducing effects if it were implemented alone.

3. Traffic Engineering Improvements

- Traffic flow can be improved by a number of small projects which would redesign intersections or small street segments. However, if overall capacity were increased, and more trips generated, there could be a negative air quality effect.

- This measure was dropped because it would affect only a small portion of travel, and any air quality effects would likely be insignificant.

4. Off-Street Freight Loading

- Zoning regulations could specify off-street freight handling, which would improve traffic flow and hence air quality.

- The improved flow would have very little effect on oxidant precursors. Thus this measure was dropped.

This general class of controls is designed to improve air quality by smoothing the flow of traffic. Since certain emissions increase due to stop and go traffic conditions, smoothing traffic flow would help reduce overall emissions. Traffic flow improvements are particularly suited to alleviating carbon monoxide problems. However, because of increasingly stringent motor vehicle emission standards for new cars, CO is not expected to be a long-term problem in the Bay Area. Thus, these tactics will not be studied extensively as part of AQMP.

I.B. MEASURES TO REDUCE PEAK-PERIOD TRAFFIC VOLUMES

1. Staggered Work Hours

- This program would shift the daily work schedule so that all employees would not arrive and leave at the same time. This could take the form of "staggered hours," where subgroups of a total work force operate on a fixed schedule, or "flextime," where employees are given the option of determining their own hours within certain limits. This measure could improve air quality by a) reducing congestion, b) spreading early morning emissions, and c) providing employees with an opportunity to adjust their schedules to accommodate other modes of travel.

- This measure will not be studied further because it would only redistribute auto trips, rather than eliminate them.

2. Four Day Work Week

- The standard work week would be shortened to four days, with the work day lengthened and/or the weekly hours worked shortened. Presumably, one-fifth of the commute travel would be eliminated, but the additional leisure time would probably generate other recreational or shopping trips.

- Because of the potential for more trips on the additional off-day, it was felt that this measure would have only a small effect on air quality, and so was not included for further study.

3. Off-Peak Freight Delivery

- Freight deliveries would be prohibited during peak periods. This would both reduce peak period traffic and also improve traffic flow by removing the slower vehicles and the trucks stopped while loading.

- Only a small percentage of regional travel would be affected by this measure, and so any air quality improvement would be virtually undetectable. This measure was therefore dropped from further consideration.

II. MEASURES TO REDUCE VEHICLE USE[7]

A. Measures to Restrict Vehicle Ownership

This strategy is designed to reduce travel by limiting the number of vehicles. The possible measures are the following:

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[7]Hoffman, Wayne J., California Transportation Plan Task Force Issue Paper II, "Environmental Impacts: Air Quality, Natural Environment, Noise," May 1976.

1. Additional License Fee

- This measure could take a number of forms. It could be a tax increase on all cars, or one which would put a progressively heavier tax on the more polluting cars. Another alternative would be to tax second or third cars and to reduce mobility.

- Although this measure is appealing from an implementation standpoint, at least one study (8) has indicated that an annual fee would not be a significant factor in someone's decision to own or drive a car, unless the fee was excessively high. This measure was thus dropped from further consideration.

2. Registration Limits

- Instead of taxing vehicles with higher pollution potential, this measure would set limits on the numbers of such vehicles which could be registered. The EPA promulgated TCP proposed limiting motorcycle registrations to the total registered in 1973, but this measure was dropped in the final version.

- The implementation problems of this measure are formidable. Because of this, the program could not be set up at a scale which would have a significant effect on air quality. This measure will therefore not be studied further.

Much of the peak oxidant problem can be traced to emissions generated during the morning hours. This is due to the time required for photochemical reactions to take place. Any reduction or spreading of these early morning emissions could presumably reduce intensity and location of peak oxidant concentration experienced. However, the measures in this category would be difficult to implement to the degree necessary to have a significant effect. Also, the possible displacement of the exidant problem from one hour to another would be undesirable.

II.B. MANAGEMENT OF AUTO ACCESS

The strategy here is to discourage auto use by restricting the areas where autos can travel or park. The following measures could accomplish this:

1. Better Enforcement of Parking Regulations

- There are many parking regulations on the books which, if enforced, could discourage certain auto trips. Notable among these are the restrictions on long-term, i.e., parking which would persuade some commuters to take transit. Other actions, such as enforcement of truck loading zones, could result in a smoother flow of traffic.

- To maximize their effectiveness, all parking strategies are being combined into an overall parking strategy.

2. Limit Number of Parking Spaces

   - The intent of this measure is to reduce the available parking and so limit the number of autos which can effectively use the controlled area. There are two levels: one would be to limit the construction of new parking facilities; the second would be to cut back the number of parking spaces already available.

   - This measure was added to the overall parking strategy.

3. Prohibit On-Street Parking During Peak Hours

   - This measure is designed to improve air quality primarily by improving the flow of traffic. It also works to discourage certain trips since it is limiting the available parking.

   - This measure was added to the overall parking strategy.

4. Area License

   - A special license would be required to bring a car into certain designated areas. This would encourage people to shift to other modes within the affected area, and presumably this tendency would carry over to the entire trip.

   - Although this measure is relatively untried, it does have potential, and so will be tested as part of the AQMP.

5. Auto Free Zones

   - This measure involves the designation of areas within a city (e.g., CBD's where vehicles are prohibited, with the exception of buses, taxis and emergency vehicles. This technique can result in an improved pedestrian environment and would encourage people to use transit for the entire trip. To develop vehicle-free zones, provisions need to be made for re-routing of through traffic, necessary freight movements, improved transit access, and in some cases, parking structures on the fringes. This concept has proved successful in a number of cities, mostly in Europe. In the U.S. the major examples of such zones have been shopping malls.

   - This measure will be tested for certain CBD's within the region.

6. Gas Rationing

- This is usually the measure of last resort, where the supply of gasoline is limited in an effort to cut travel and hence emissions. This measure would have significant administrative problems.

- This measure will be held in reserve against the possibility that that all other less restrictive measures would not prove effective to meet the standards on time.

II.C. MEASURES TO INCREASE COST OF AUTO USE

Another way of discouraging auto use is to make the auto user pay more. However, it generally takes a fairly stiff increase to get people out of their cars. But, in combination with bus and carpool incentives, this does appear to be a promising strategy.

1. Road Pricing Techniques

- This measure could take on two forms. In one, a fee is charged for the use of certain roads. This is similar to a toll, except that it is more widespread and would likely not be collected at a tollbooth. Instead, some system of in-car meters or electronic scanning devices might be used as automatic billing devices. The second form is a congestion toll, where the rates would increase with the level of congestion.

- These measures have not yet been tried as air quality strategies. The technology is not readily available for the first and the second is still fairly new and untested. For this reason, this measure is not being considered for further testing.

2. Increased Parking Costs

- The intent here is to discourage auto use by increasing the cost at the end of the trip. The effectiveness of this strategy depends upon the intensity of development and the availability of transit alternatives. One study of parking rates in Pittsburg estimated that a $.87 daily increase in parking rates would decrease local CBD VMT by 5.3%.[5]

- This measure will be tested as part of the AQMP. Several variations of changes within the CBD's will be tried, and probably one regionwide test would be run, in which free parking would be eliminated.

3. Increased Fuel Costs

- The gas tax could be raised to reduce the demand. The extra revenue could then be used to finance transit improvements or other non-auto alternatives. Unfortunately, the energy

crisis of 1974 demonstrated that, even with a rather large increase in cost, the use of autos did not decrease significantly. This experience showed that a 10% increase in pump price facing the consumer would cut the demand by only 1.5%.[5] In the long run, the application of this measure would probably produce a shift toward smaller, more fuel-efficient cars. The imposition of this measure raises questions of equity, since the poor and those not having access to transit would be penalized most severly.

- This measure will be tested for several different increases.

4. Increased Tolls

- Bridge tolls could be increased to reduce the volume of autos using the facility and to generate revenue which could be used to finance improvements in the transit system. MTC was recently given authority over the level and use of tolls on the trans-bay bridges. An increase to $1.00 has been proposed for this year.

- This measure will be tested with a possible variation for carpools.

5. "Smog Charges"

- This measure would basically charge the auto driver for the pollution his car generates. If properly designed, this would encourage a shift to other forms of transport or to less polluting cars. The implementation could be done through some of the measures already mentioned, such as the gas tax or registration fee. This might have to be accompanied by some rebate scheme for those autos with superior emissions control equipment.

- The effectiveness of this measure will be estimated from the results of other measures such as the gas tax.

II.D. MEASURES TO REDUCE THE NEED TO TRAVEL

This strategy would encourage travel substitutes. Unfortunately, the implementation of such measures is rather uncertain, and the effects, such as effectiveness or public acceptance, are also unknown.

1. Communications Substitutes

- Certain trips could be eliminated by using other means of communications. This can include business trips and sometimes shopping trips. The technology for visual communications is becoming more readily available. However, the extent to which the public will adapt to these new systems is uncertain.

- This measure was dropped because effectiveness in the study period is doubtful.

2. Goods Movement Consolidation

   - This measure would reduce truck VMT by consolidating freight deliveries. Basically, the concept is to have one terminal where the freight is delivered and sorted, and then small trucks would deliver from there. The measure would thus decrease truck VMT and probably reduce auto emissions as well by permitting a smoother traffic flow.

   - The effectiveness of this measure would be minimal because of the small percentage of travel that would be affected. The measure was thus dropped.

III. MEASURES TO ENCOURAGE ALTERNATIVE MODES OF TRAVEL[8]

A. Increase Transit Ridership

These measures provide incentives for transit as an alternative transportation mode. People must be given an alternative if we wish to divert them from the automobile. For many trips, transit is a very viable option. The following measures are designed to promote the transit mode.

1. Additional Transit Service

   - Increasing the transit service would increase its availability, decrease the waiting time and in some cases the running time, and in general make transit more competetive with the auto.

   - This measure will be tested, although the precise form has not been determined as yet.

2. Fare Reductions

   - There are a number of variations of this measure. One is to simply reduce or eliminate transit fares. This would probably not be very effective, since the fares throughout the Bay Area are already relatively low. A second option is some form of a monthly pass. This has good potential, since it would eliminate the psychological impediment of paying each time, and so would encourage the diversion of casual trips to transit. A related option is the coordination of transfers between systems.

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[8] Planning Environment International, "Transportation Management Tactics for Air Quality Improvement," April 1976.
R. H. Pratt Associates, Inc., "Transportation Controls for Air Quality Improvements in the National Capitol Region," October 1976.

- The effectiveness of the measure will be estimated from experience in other areas.

3. Improved Transit Comfort

- This measure seeks to reduce the differences between the auto and transit modes by improving the comfort of transit service. This could be done by providing shelters at bus stops, better security, more comfortable buses, or other amenities.

- It is believed that amenities alone would not significantly influence transit demand. Also, most of the new buses going into service will incorporate many amenities. Thus, this measure was dropped from consideration.

4. Bus and Carpool Lanes

- Exclusive lanes for buses and carpools would be provided to give these vehicles a time advantage over single occupant autos. This measure is particularly effective at congestion bottlenecks. Experience in the Bay Area has shown that although the time saving is not really large because the congested areas are short, the buses have benefitted in that they are able to maintain more reliable schedules. In the Bay Area, these lanes have been implemented on Route 101 in Marin County, Route 280 in San Francisco, through the Bay Bridge Toll Plaza, and other points on freeways. There are plans to institute others, for example along Route 580 from the Livermore Valley to the Bay Bridge.

- This measure will be tested, but specific details have not been determined.

III.B. ENCOURAGE THE PEDESTRIAN MODE

For short trips, walking is frequently the best alternative. Providing amenities such as wider pavements, or moving sidewalks between major activity centers, can encourage people to walk for short trips. While the measure does not significantly reduce VMT, it can have an important effect on emissions since the auto emission devices take a while to reach maximum operating efficiency.

The effectiveness of this measure will be estimated from experience in other areas.

III.C. MEASURES TO ENCOURAGE THE BICYCLE MODE

One strategy that could be particularly effective is the greater use of bicycles for the short utility trip and interface with transit on the commute trip. During the summer and fall months, the weather is ideal for cycling, and the daylight is long enough to provide sufficient time for such trips.

The two major deterrents to the extensive use of bicycles have been safety and theft. The first, as statistics bear out, could be greatly improved through education, acknowledging the bicycle as a legitimate mode and requiring similar knowledge and qualifications for its use as now is required for drivers of cars. Safe parking for bikes, particularly lockers at transit transfer points, shopping centers and other places, is possible with minimal capital outlay ($175 per locker vs. about $5,000 per parking stall or structure) and would do much to stimulate bicycle utility trips.

Since utility and commute trips on bicycles are the ones most likely to reduce VMT, initial emphasis should be placed on providing extensive mileage of bike routes for those purposes rather than for recreational use.

- This measure will also be studied using data from other areas.

III.D. MEASURES TO ENCOURAGE RIDE SHARING

Carpooling has good potential as a strategy for reducing vehicle travel. It requires no new capital investment since the cars are already available. It can offer many amenities that transit cannot, such as door-to-door service. Finally, the cost savings are easily perceived by the individual riders.

The following measures can promote this goal:

1. <u>Toll Reduction for Carpools</u>

   - One means of encouraging carpools is to reduce or eliminate the tolls on bridges or other toll facilities. This measure is more effective at higher tolls. Currently, the trans-bay bridges charge no tolls for carpools between 6 a.m. and 6 p.m. The Golden Gate Bridge also allows free passage of carpools.

   - This measure will be tested as a partial reduction in carpool costs.

2. <u>Preferential Parking for Carpools</u>

   - Special lots would be reserved for carpools which would offer an advantage in location and/or price. CALTRANS is currently leasing state lots in San Francisco which will be available to carpools for no more than $10/month. Other fringe parking lots are being planned which will aid in carpool pick-ups.

   - This measure will be tested as a time-and-cost savings to carpools.

3. <u>Carpool Matching Information</u>

   - These programs are oriented to providing assistance to those individuals interested in forming carpools. Typically the programs attempt to match riders going to common destinations from common origins with common work schedules.

This section describes a concept to structure land development policy alternatives for testing in the various AQMP control strategy proposals. The descriptions of alternatives are general at this time and will be detailed further as discussions continue at staff and advisory committee levels and more specific information can be developed. This more specific information will include both technical and institution descriptions of the land development alternatives. Technically they will be described in quantitative terms: acres, housing units, population, employment, etc. Institutionally they will be described in terms of the agencies and policy instruments that could accomplish the alternative.

The testing of land use alternatives for air quality implications is a recent advance in regional analysis capability. It is now possible largely because of the advent of the LIRAQ air pollution computer model for the Bay Area.

It will be possible to test a full range of land use alternatives. These can be carefully developed such as the base cases which are run through the entire series of regional models--PLUM, MTC Travel Models and LIRAQ. Alternatives to base cases will be structured as discussed in the following pages to represent real world possibilities. However, it will be possible to work with LIRAQ in a preliminary way to test the air quality impact of large changes in development in various subregional areas to develop a "feel" for land use management possibilities. This preliminary sketch planning can be done by manipulating the LIRAQ emission grid to represent changes in development location or density. This technique will also provide a better understanding of the effects of wind transport of pollutants from one area to another.

STRUCTURING TECHNICAL AND INSTITUTIONAL ASSUMPTIONS

The ABAG Series 3 Provisional Projections of Population, Employment and Land Use constitute the base case assumption about land development for air quality assessment - essentially assuming that current local land development policy will remain unchanged over both the short term period to 1985 and also the longer term period from 1985 to 2000, and that no significant regional policy will have effect.[9]

Alternative configurations to this current policy/trend will need to be structured based on the findings of that assessment. The conceptual structure for such alternatives can and should be set before those assessments of the base case are complete. The structure should require clear documentation of the technical assumptions that would be associated with extreme assumptions about when and where development of what type and

[9] The base cases will also be assessed for impacts other than air quality including non-environmental impacts such as economic (production, income and investment consumer expenditure) and social (housing supplies, physical mobility, health and safety).

density would occur. It should also require clear documentation about what changes are assumed in the way local and regional agencies would work together to carry out those technical assumptions about land development.

Technical Assumptions

Technical assumptions about land development policy can be structured around those key aspects of land development that can be related both to specific jurisdictions with specific policy instruments, and to specific ways ABAG's analytic "land use" models can represent the alternatives for purposes of testing and assessment. Those aspects are the timing, quantity, location, density, and type of land development. By technically addressing these aspects a major U.S. HUD requirement for the regional "land use element" is also satisfied.

Institutional Assumptions

In the current policy framework of the Base Case projections these same aspects of development can be ranked with respect to the degree that they are presently dealt with from the local level to the regional level.

Timing of development is currently reflected in only a very few local development policies. It may become the most important regional aspect of development in the alternatives, in treating the assumptions of when the air quality standards will be met.

Quantity of development is currently reflected in a few local development policies. Those having the most effect are keyed to service capacities of existing and committed sewer systems. Water supply is just now becoming a critical assumption in terms of absolute quantity as well as location. Quantitative controls, together with timing, may become much more important at the regional scale for air quality objectives than it currently is for local development and service objectives.

Location of development is currently dealt with most effectively at the county level by the Local Agency Formation Commissions (LAFCOs). At regional scale the current regional trend continues to focus development southward, but alternatives may need to assess the hows and whys of encouraging more development in the north bay counties. Another locational option to be considered is focusing development inward to older development locations as a function of policies on clearance and redevelopment (both public and private), densification and conversion of existing structures, and infill of bypassed vacant land.

Density of development is currently an exclusively local concern. The current regionwide aggregate of local policy is notable for much lower densities than have occured historically. A more consistent regionwide focus on density related to air quality concerns will need to supplement the likely parallel focus on higher density options as related to better urban services, most notably transit service and feasibility.

Type of development has also been an exclusively local prerogative dealt with primarily through zoning. Issues related to the balance of housing and jobs are currently surfacing in terms of local tax revenues and service costs. The regional implication to air quality, especially via the number and length of automobile trips will likely be one of the dominant findings in the assessment of current development policy regionwide. Sensitive as it may be, some regional role with respect to type of development should be examined in alternative land development scenarios.

In the current policy/trend assumptions of the Series 3 Provisional Projections there is considerable variance in which of the five development aspects are effectively dealt with in different jurisdications. For example, Petaluma is one of the very few jurisdications that deals specifically with timing and quantity of development with its now famous growth management program, as well as dealing more traditionally with location, type and density through its zoning laws. Many more traditional jurisdictions deal specifically only with location, type and density.

Generally then assumptions about regional policy intervention in land development are virtually absent from the base case option. Those aspects with least current attention at local level - quantity and timing of development - may be the most important aspects to structure technical alternatives in the air quality plan. Institutionally, these two aspects will require much more attention in both the short term and the long term future. In the short term, the institutional assumptions may be keyed to more effective application of existing institutional arrangements among local jurisdications. For example, under current legislation county LAFCO's could play a much more dynamic role in clarifying city and county development policy in terms of location and timing than they typically do now. Santa Clara County currently does much more in terms of development timing than do other county LAFCO's. In the longer term the institutional assumptions could focus on changes in legislation to clearly enable local jurisdictions to do more in terms of quantity and timing, especially as regards the policy linkage between cities as local regulators and special districts as providers of essential services.

In the alternatives much attention will need to be given to combinations of jurisdictions and policy tools potentially dealing with more of the development aspects. This could involve institutional structures similar to those already in effect in Santa Clara County among the county and its cities. It could also involve the assumption of a greater role in aspects of local development by state or regional bodies.

One further essential item to be considered in the structuring of alternatives covers those departures from current local policy that are already under consideration in may local jurisdictions. Massive changes in density regulations, and new policy frameworks keyed to the timing of development (ala Petaluma) and housing/industrial balance for fiscal objectives are but two of many that are already significant.

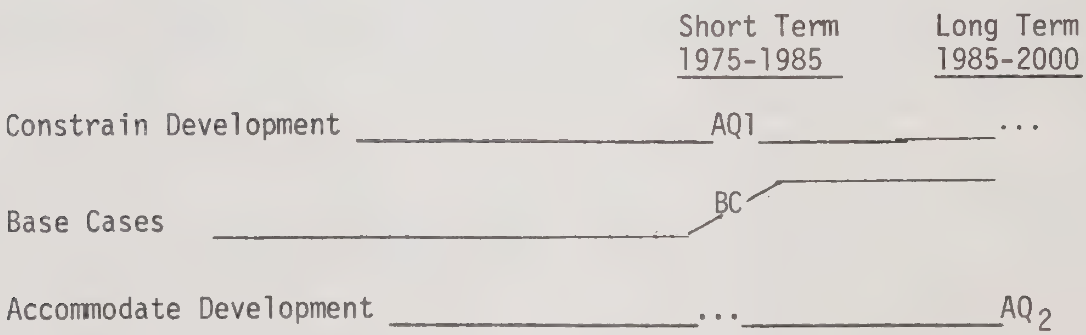
Alternatives Which Represent
Extreme Cases

While assessment of the Base Cases projections proceeds, other case alternatives can be structured which anticipate that the base case situation is neither the best nor the worst likely option in terms of the environmental mandates. "Best case" and "worst case" alternatives which on one hand assume air quality objectives will be achieved in the ten year short term time period (by 1985) and on the other hand assumes they will not be met perhaps even in twenty years. In general, the air quality "best case" is presumably one that constrains growth, especially in the short term time frame - this might be considered by some to be the "worst case" for achievement of social/economic objectives. Conversely, the air quality "worst case" of delayed air quality objectives may constitute an alternative that largely accommodates the growth trend through both the short and long time frame - possibly the "best case" for social/economic objectives.

Examples of such conceptual alternatives, as described in detail in later sections of this discussion paper, would probably bracket the Base Cases as shown in Figure 1.

Figure 1

Conceptual Alternatives
Which Bracket Base Cases



AQ1 = Air Quality Best Case
AQ2 = Air Quality Worst Case

Base Cases, in this example, are close to the Accomodate Development Alternative in the short term but have proven to be notably constraining in the long term.

With this concept, the extreme alternatives can be described as:

1) Constrain Development in the short term (1975-1985) to represent the extreme land development option that might be necessary to

achieve clean air by 1985 if the 1985 Base Case is assessed (as expected) as not achieving that objective. In the short term this alternative would probably assume relatively little change in local land development policy with local jurisdictions moving only slowly to change their traditional focus on type, density, and location of development. The likely needed focus on controlling quantity and timing of development in the short term period would have to be assumed to come from state or regional intervention similar to the "E-O" limits on sewage treatment plant hookup permits. In the longer term from 1985 to 2000 the constrain development alternative would likely get into more innovative assumptions regarding local jurisdictions controlling quantity and timing of development similar to the Petaluma plan, but keyed specifically to air quality objectives.

2) Accomodate Development through the short term into the long term to achieve air quality objectives delayed to 1995. In the short term, the accomodate development alternative would probably be only slightly different than Base Cases with a deeper focus on the density aspect where the extreme low densities of current local policy may need reexamination even in terms of meeting local non-environmental objectives. In the key long term period the accomodate development alternative would assume local jurisdictions able to service both intensive and extensive development but with a more balanced regionwide housing/jobs location policy than is now the case.

The two alternatives are described in greater detail in the following sections and are included in the summary table at the end of this paper.

DESCRIPTION OF CURRENT POLICY/TREND (BASE CASES)

The Current Policy/Trend as represented in the Base Cases assumes no regional land development intervention. Local policy, in aggregate, is the regionwide policy base.

Timing - No regional timing controls were assumed. The only significant local timing controls were the Petaluma plan (500 du/yr) and the Santa Clara County "Urban Service Area" annexation policy as carried out by the LAFCO This joint city/county policy plan relates the timing of urban development to the committed capacity of urban services.

Quantity - No regional quantitative controls were assumed in Base Cases other than those few sewer service capacity limits being carried out by local service agencies. The city and county of Napa have quantitative policy statements keyed to population limits that are being carried out via regular land use controls.

Location - Continue to assume no effective regional policy to redirect the dominant southward trend of development at least until 1985. In localities with air quality problems it might entail assuming only those locations with full service commitments ("Prime" in Base Cases) would be allowed to develop, with the lower potential rural development areas held in moratoriums of one sort or another.

The longer term Constrain Growth alternative could assess new directions such as, at regional scale, the much maligned "GroNorth" of ABAG's Series 2 projections. Also in the longer term, but at local scale, the constrained growth alternative could assume all land within city spheres of influence as developable. A large quantity of such land is currently deferred or excluded from development due to agriculatural preservation or to lack of service commitments. All land outside such spheres, usually of the low density poorly serviced variety would be assumed as not developable. A significant departure from this could include "new towns" outside of established spheres where the county wishes to assess the implications of such an option, but on the basis that it would be a balanced community in terms of housing and jobs rather than a "bedroom suburb"

Another element of development location that could be accounted for in policy alternatives is "in-fill", the development of bypassed scattered vacant parcels. Policy incentives to develop such locations might be included in a constrain development alternative under the rational that such locations have been bypassed in the relatively unconstrained current policy situation, in favor of peripheral locations. Public incentives, subsidies, facilities or whatever would presumably be undertaken at the expense of such commitments at the periphery. No clearcut in-fill policies were found in the Local Policy Survey so it is doubtful that more than a few could be assumed in the short term. Major assumptions in this regard might be suitable in the longer term alternatives.

Density - In the short term, it is assumed that massive policy changes regarding density are not realistic and that the generally low density policy of Base Cases will continue. In the longer term beyond 1985 major densification could be assumed for some locations with short home-to-work trip potential or those located in existing or planned transit corridors (e.g. the east bay plain and central Contra Costa County BART corridor).

Type - Again, the short term future would be assumed insufficient for major policy change not already contemplated. At regional scale no policy shift would be assumed. At local level some housing/jobs balance controls could be assumed for those jurisdications where they are already well on the way toward adoption.

In the longer term, the issue of housing/jobs balance might be addressed at regional scale, perhaps as the basis for locational alternatives such as the above discussed revival of the "GroNorth" option, together with assumptions about limited new regional transportation facilities.

Location - At regional scale the location of development is the statement of its directional thrust. The recent historical trend of development to seek southbay suburban locations is assumed to continue in the Base Cases. At local scale the prime development locations are documented in Base Cases as lying within LAFCO defined city spheres and being approved for development with existing or committed services. The low potential secondary locations are generally defined as being outside LAFCO defined city spheres and lacking service commitments and/or having flood, slope or other hazardous area regulations in force.

Density - No consistent regionwide density is assumed in the Base Cases - only the aggregate of individual local jurisdiction policy as expressed in the zoning ordinance, and documented at the census tract level.

Type - Base Cases assume no regional policy as to type of development. The Base Case projections of land use by type are the acreage necessary to accomodate the regional projection of housing and employment at the locally prescribed density. Specific local zoning for residential (and commercial), industrial and open spece were the land use type ingredients in the Base Cases.

DESCRIPTION OF THE CONSTRAIN DEVELOPMENT ALTERNATIVE (AIR QUALITY "BEST CASE")

As already indicated, the key assumption in the Constrain Development Alternative is that the timing mandate for meeting air and water quality standards will be met in the short term, by 1985 and continue to be met into the longer term future. The major policy difference from current policy would entail some representation of air quality problems being resolved within 10 years by quantitative controls probably on residential and non-residential construction via permit moratoriums and land development moratoriums in those low density "sprawl" areas identified as contributing to the vehicular travel demand and air pollution ("low development potential" secondary land in Base Cases).

Reviewing all five aspects as to the sort of regional and local policy assumptions that could be included in a Constrain Development Alternative:

Timing - Delay of development in air quality problem areas via regional reviews and funding allocations. Some local timing controls represented for those jurisdications which are already considering such devices (e.g. already heard by planning commission, pending council review) such local controls would probably not be assumed until 1980.

Quantity - No regionwide quantity policy would be assumed; only the total regional projections. Local "lids" as already current in Base Cases could be assumed but supplemented by local permit and development moratoriums as discussed above, under Timing.

DESCRIPTION OF THE ACCOMODATE DEVELOPMENT
ALTERNATIVE (AIR QUALITY "WORST CASE")

The key assumption in the Accomodate Development extreme alternative is the delay of the environmental mandates until at least 1995. The major policy difference from Base Cases is the assumption that most existing restrictive local controls would be lifted after 1985 and no new constraints, either local or regional, would be brought to bear. Implicit in these assumptions is that local jurisdictions will find the fiscal means to serve such development, including regional tax sharing or the like, and that regional scale services such as transportation would be the only major limits.

Reviewing all five aspects of development as to the sort of regional and local policy assumptions that might be included in an Accomodate Development Alternative:

Timing - No regional timing controls in either the short or long term. Some local timing controls now in effect or now under policy consideration could be assumed for the short term and dropped for the long term, beyond 1985, on the assumption that facility and service needs will be met "on time".

Quantity - Again, the projections of total regional growth would be the only regional limits - an assumption of reasonable expectation not of regional policy. Most service related local quantitative "lids" would be dropped in both the short and long term on the assumption that service needs can be met. This latter assumption would need to be documented as to what it would mean fiscally with some assumption of the source of local funds for those services.

Location - The regional assumption would assume the continuation of the south bay growth trend in the short term, and could include something like the "GroNorth" option for the long term if it appears needed to accomodate the projections of total regional growth in both jobs and housing.

To supplement this, the local policy assumptions could include all land with any Base Case development potential, inside or outside of LAFCO city spheres, as fully developable in the short term. This again, is a major assumption about local jurisdictions service capacity in the near future. The long term accomodation could include expanded LAFCO spheres in conjunction with urban densities for such now rural areas, or the assumption that current rural density policies will be so built (20-40 acre lots).

Density - The accomodate development alternative would probably continue the current local policy densities (typically very low density) for the short term but then densify all locations after 1985 in keeping with "market demand". No major regional role in formulation or implementing density policies is foreseen in this option. Thus the assumption that all local jurisdictions will "jump on the higher density bandwagon" is a tenuous one.

Type - The accomodate development alternative would probably not differ at all from the Base Cases, in either the short or long term planning periods, with respect to management or control of housing/job balance.

A RANGE OF LAND USE ALTERNATIVES

For consideration in the AQMP, five scenarios or alternatives are presented for more detailed consideration and analysis.

1. Constrain Development (Air Quality "Best Case")

   In the ten year short term encourage local governments toward a more compact higher density land use pattern with stringent controls to delay or totally bar development in the most critical air quality locations. Beyond ten years very stringent control of suburban "sprawl" with higher densities in transit corridors and incentives for "infill" development and redevelopment. Housing/jobs balance controls would be included in some jurisdictions in the short term period, and for the total region in the longer term.

2. Base Cases - (Current Policy/Trend)

   Essentially a continuation of south bay suburban "sprawl" with very low densities and extreme home-to-work distances. In the short term accommodates development up to limited service capacities of local jurisdictions. In the long term becomes very constraining as developable land (in terms of local service capacities) runs out.

3. Accommodate Development (Air Quality "Worst Case")

   Essentially a combination of the higher densities of the constrain development alternative together with accommodation of some extensive development. In the short term development would be limited to land specified developable in base cases but in the longer term would be opened to more extensive development generally at higher densities in most locations.

4. Combinations of Above

   After evaluation of the "trade-offs" in the above 3 cases the best aspects of each could be combined into an alternative that cannot be described at this time. For example, the most achievable aspects of the AQ "best case" might be combined with the least objectionable aspects of the AQ "worst case" to structure a most readily acceptable alternative.

5. No Growth

   An "academic" alternative assuming no development at all could be structured merely to examine the effectiveness of non-land use controls in the absence of additional land use related sources and land use controls.

CONTROL MEASURES RETAINED FOR FURTHER STUDY

This Tech Memo has described the process used to make the initial cut of the original lists of proposed candidate control measures. The measures surviving the preliminary screening are shown in Table 4. These measures will be studied in the next phase of work to determine feasibility of implementation. Information on a full range of environmental impacts will be developed to insure that the effect of each measure is understood before it is proposed for testing by itself or in combination with other measures.

The results of this analysis, testing and further screening will be documented in a future Tech Memo.

TABLE 4

CONTROL MEASURES AND TACTICS RETAINED FOR FURTHER STUDY

STATIONARY SOURCE MEASURES

- High solid & Water Base Coatings
- Closed System Organic Storage
- Limit Max SO_2 to 300 ppm or equivalent mass
- Fuel conversion
  a) Limit at 0.25% S
  b) Control equipment
- BACT on new and existing sources
- Continue NSR with some sort of trade off
- Lower reid vapor pressure of motor vehicle gasoline 3 PSIA
- NO_x control for off-highway equipment
- NO_x limits for all new bodies
- Lower particulate emission grain loading limit
- Tighten process weight regulation
- Plant operation scheduling

MOBILE SOURCE EMISSION MEASURES

- More stringent exhaust emission controls
- More stringent evaporative emission controls
- Retrofit programs
- Emission standards for other mobile sources
- Motor vehicle inspection/ maintenance program

TRANSPORTATION CONTROL MEASURES

<u>Improve Traffic Flow</u>

- Ramp metering

<u>Management of Auto Access</u>

- Parking regulations
- Limit parking spaces
- No peak hour street parking
- Area license
- Auto-free zones
- Gas rationing

<u>Increase Cost of Auto Use</u>

- Increased parking costs
- Increased gas tax
- Increased tolls
- "Smog changes"

<u>Increase Transit Ridership</u>

- Additional transit service
- Fare reductions
- Bus and carpool lanes

<u>Encourage Pedestrian Mode</u>

<u>Encourage Bicycle Mode</u>

<u>Encourage Ride Sharing</u>

- Toll reduction for carpools
- Preferential parking for carpools
- Carpool matching information

<u>Promote Para-Transit Alternatives</u>

LAND USE/DEVELOPMENT CONTROL MEASURES

More effective management of all five major aspects of land development through coordinated action by cities, counties, special districts, or regional and State agencies to reduce the magnitude and frequency of auto travel:

- <u>Timing</u> - expand the presently very limited application of timing controls such as growth sequence zoning, building permit quotas, staging of sewer and water intrastructure and plant capacities, etc.
- <u>Quantity</u> - expand the presently scattered application of quantitative controls on development such as performance standard zoning and limited sewer and water infra—structure and plant capacities.
- <u>Location</u> - Improve the presently inconsistent application of controls on the location of development such as coordinated management of infrastructure location, annexations, public land acquisition, agricultural preserves, hillside and soil conservation, and development moratoria.
- <u>Density</u> - Encourage transit usage and other non-auto modes with coordinated density policies among local jurisdictions through the application of innovative density zoning mechanisms (slope density, building height regulations, etc.) fully coordinated with service capacities and committments.
- <u>Type</u> -Reduce home-to-work & home-to-non-wo travel by encouraging more land use mix, especially in terms of housing/jobs balance.

July, 1977

THE AQMP: LEGAL REQUIREMENTS

Introduction

Federal Clean Air legislation requires that air quality maintenance plans be developed for areas expected to exceed any National Ambient Air Quality Standard (NAAQS) because of present air quality and/or projected growth. The purpose of this paper is to briefly highlight the substantive and procedural regulatory "touchstones" to be acknowledged as an Air Quality Maintenance Plan for the San Francisco Bay Area. Summarized are elements either directly mandated by the legislation or prescribed by the U.S. Environmental Protection Agency in the Code of Federal Regulations.

Statutory Authority

The Federal Clean Air Act Amendments of 1970 required that States develop implementation plans (SIP) that provide for the attainment and maintenance of primary and secondary standards in prescribed air quality control regions (or portions thereof) within their boundaries.[1] Section 110 of that legislation specifically provides that such plans must include "emission limitations, schedules and timetables for compliance with such limitations, and such other measures as may be necessary to insure attainment <u>and maintenance</u> of such...standard(s)...including, but not limited to, land use and transportation controls..."[2]

Regulatory Background

Also in accord with the 1970 legislation are U.S. Environmental Protection Agency (EPA) regulations that require States to identify areas within their boundaries where attainment of standards by 1977 is not predicted, or where growth and development over the ten-year period 1975-1985 may interfere with either attainment or maintenance of the standards once achieved.[3] An air quality maintenance plan is to be developed for each pollutant expected to exced the relevant standard, which provides for the attainment and/or maintenance of that standard for a ten year period (beginning from the date of submittal).[4] Upon formal adoption, the plan will constitute a Revision to the State Implementation Plan governing the area for which it was developed.

Air Quality Maintenance Requirements

EPA regulations require that certain procedural steps be followed during plan development and ultimately during plan implementation, to ensure that an opportunity exists for broad-based evaluation of the relationships between air quality objectives and other community goals.[5] Accordingly,

40 CFR 51.58 identifies intergovernmental cooperation as a key element in the air quality maintenance planning process, and requires that a structural framework be created for cooperative execution of the AQMP process. Evidencing the successful existence of such a framework will be its capacity to accommodate: coordination between the plan development effort and potentially affected agencies; coordination between the AQMP and other planning programs; coordinated implementation of the AQMP with AQMP's being implemented in adjoining areas in the State; and a coordinated system of review that permits the cognizant areawide and state clearinghouses to comment on the AQMP prior to submittal for approval.[6]

In addition to procedural requirements, EPA regulations also require that a number of substantive considerations be undertaken during AQMP development. Existing emissions data are to be reviewed and documented as a prerequisite for use in formulating maintenance strategies.[7] The relationship between such information and current ambient air quality data must be identified and together with present aggregate emissions, projected to estimate future air quality conditions.[8] The projection is to span a predetermined analysis period and is to be no less than 10 years in duration.[9] Projected emissions are to be allocated at a sub-county level throughout the air quality maintenance areas for each pollutant requiring a maintenance strategy.[10] An analysis of the air quality maintenance areas must then be performed to determine the impact of growth and development on air quality for the forecast period. Where the analysis indicates that ambient air quality standards will not be maintained (or attained) strategies must be developed that provide for control or accommodation of the increased emissions expected to result from such growth and development.[11]

The final category of EPA-AQMP regulations relate to plan content and submittal format requirements. Specifically, an approvable plan must demonstrate that the measures, rules and regulations contained in the plan are adequate to provide for the attainment and maintenance of the national (and state) standards for a reasonable period of time. Provision of such a demonstration requires that the following be included in the AQMP for expected attainment years:

"(1) A summary of the computations, assumptions, and judgements used to determine the reduction of emissions that will result from the application of the AQMP plan.

(2) A presentation of emission levels expected to result from application of each measure of the control strategy...

(3) A presentation of the air quality levels expected to result from application of the overall control strategy presented either in tabular form or as an isopleth map showing expected maximum pollutant concentrations and expected concentration gradients."[12]

Another required characteristic of the air quality maintenance plan is that it demonstrate that the State or a substate entity has adequate legal authority to enforce all proposed measures.[13] A description of each control

measure and the enforceable laws and regulations (existing or proposed) required to implement it should be incorporated into the plan. In addition, a description should also be included of administrative procedures and enforcement methods that are expected to be used in implementing each selected maintenance measure. Finally, the plan should describe the relationship between the overall control strategy and the implementing agency's (State or substate) procedure for review of new and modified sources.[14]

Future strategies necessary to maintain national air quality beyond the analysis period should be discussed as well as the laws and regulations required to support them. Adoption of requisite legal authority should occur sufficiently prior to when compliance is necessary, to ensure the maintenance of the national standards. Guidance should be sought from EPA in determining what constitutes sufficient time.[15]

References

1. Clean Air Act (42 U.S. Code 1857 et seq., as amended by the Clean Air Amendments of 1970, Pub. Law 91-604), Section 110(a)(1)-Implementation Plans.

2. Ibid, Section 110(a)(1)(B).

3. Volume 40, Code of Federal Regulations (CFR), Part 50, Section 51.12(e) (as revised July 1, 1976).

4. Note: On June 13, 1974, in compliance with Federal Regulations, the California Air Resources Board (ARB) made preliminary designations of nine AQMA's within the State. One of these areas was the San Francisco Bay Area Air Basin, which encompasses all of seven counties: Alameda, Contra Costa, Marin, San Francisco, San Mateo, Santa Clara, and Napa, and portions of two others-southwestern Solano and southern Sonoma. ARB's preliminary designation calculations show the Bay Area to be an AQMA for the following pollutants: particulate matter, oxidant, and sulfur dioxide. The EPA confirmed this designation on September 9, 1975: (40 CFR 52.267).

5. 40 CFR, Part 51, (Subpart D), "Maintenance of Standards", Section 51.58 (a)-(g), "AQMA Plan: Intergovernmental Cooperation."

6. 40 CFR 51.58(f) indicates that pursuant to review procedures prescribed by OMB Circular A-95, the AQMP must be submitted to the cognizant state and areawide clearinghouses for review and comment for a period of forty-five days.

7. 40 CRF 51.47 "AQMA Analysis: Description of Data Sources."

8. 40 CFR 51.44 "AQMA Analysis: Projection of Emissions", and 40 CRF 51.56 "AQMA Analysis: Projection of Air Quality Concentrations."

9. 40 CFR 51.42 "AQMA Analysis: Analysis Period."

10. 40 CFR 51.45 "AQMA Analysis: Allocation of Emissions"; *Note: A maintenance strategy is defined as the combination of measures designed to achieve the aggregate reduction of emissions necessary for the maintenance of a NAAQS. Maintenance measures are controls that are applicable to specific source categories, pollutants, and/or air quality maintenance problems--Guidelines For Air Quality Maintenance Planning and Analysis Vol. 2: Plan Preparation, p. v-i EPA-450/4-74-002 (OAQPS Guideline No. 1.2-021).

11. 40 CFR 51.12(h)(2) "Control Strategy: General" specifies that two review procedures are required at no more than 5-year intervals following initial AQMP development: 1) Reassessment of area designation to determine if additional areas should be designated as AQMA's or if areas currently designated as AQMA's should be deleted, and 2) reanalysis of the impact of growth on air quality and the control strategies and/or other measures adopted to ensure that projected growth and development will be compatible with maintenance of NAAQS.

12. 40 CFR 51.53 "AQMA Plan: Demonstration of Adequacy."

13. 40 CFR 51.55 "AQMA Plan: Legal Authority."

14. 40 CFR 51.54 "AQMA Plan: Strategies."

15. 40 CFR 51.56 "AQMA Plan: Future Strategies", and 40 CFR 51.57 "AQMA Plan: Legal Authority."

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DEVELOPMENT AND ANALYSIS OF ALTERNATIVE AIR QUALITY STRATEGIES

Development of the air quality maintenance plan has proceeded along two parallel paths. One path includes preparation of the data and analytical tools which are to be used for testing the effectiveness of alternative controls in improving air quality. The other path is directed toward identification, screening, and socio-economic impact assessment of the controls to be tested. This technical memorandum describes the procedure for merging these two paths.

The AQMP/Tech. Memo 5, "Candidate Control Measures", summarizes an extensive number of alternative control measures which have been identified. From this list, a very large number of permutations/combinations may be constructed to produce a variety of control strategies. On the other hand, the analytical modeling system described in AQMP/Tech. Memo 2, "Projections/Forecasting: System Description and Technical Assumptions" requires extensive resources for its operation.

The available manpower, schedule, and funding severely limit the number of alternatives which can be individually tested. To overcome this problem, the following three step procedure has been developed to maximize the amount of information generated by a minimum set of model runs:

- The first step consists of (a) evaluating individual control measures with respect to their effectiveness in reducing pollutant emissions, and (b) exercising the air quality model (e.g., LIRAQ) to determine the range of emissions levels necessary to meet the ambient air quality standards.

- The second step consists of the evaluation of a series of extreme or "limiting" cases. In each case, a particular control strategy (e.g., maximum technology, transportation control, compact land development) is developed from the list of candidate control measures. The effectiveness of each extreme strategy in improving air quality is then evaluated.

- The third step is either to assemble the "preferred strategy" or additional alternatives, and evaluate the resulting air quality. This step requires input/feedback from the Environmental Management Task Force, the AQMP Advisory Committee, and other interested parties based on the results of the first two steps.

The first step identifies the range of total emission reductions necessary, and the increments of emission reduction which may be expected from each candidate control measure. The second step measures the effects of packaging individual control measures into strategies, and the spatial aspects of each strategy. In addition, the extreme cases to be tested will directly address some fundamental issues in air pollution control. The third step is not well defined at this time since much depends on the nature of the feedback which is generated from steps one and two. The information produced in the first two steps plus the cost and social impact assessment for the candidate control measures should provide a sound basis for development of a preferred control strategy for the AQMP.

DETERMINING THE RANGE OF EMISSION REDUCTIONS NECESSARY TO ATTAIN THE OXIDANT STANDARD

The determination of necessary emission reductions requires that LIRAQ be applied in a form of sensitivity analysis which focuses on emission changes.

Thus the model will be applied in successive iterations using a number of differing hydrocarbon and NO_x emissions assumptions until the emissions levels which will result in attainment of the standard is found. Meteorological variability will be accounted for by applying the models on a minimum of two validation days which differ significantly from each other in terms of their meteorological character. The sequence of model tests will be as follows:

1. Uniform percentage reductions of both hydrocarbons and NO_x - Emissions of both HC and NO_x will be reduced by identical percentages and uniformly across the region until the oxidant standard is attained. The initial run will assume a 50 percent reduction, and subsequent runs will depend upon the results of previous runs.

2. Uniform hydrocarbon reductions only - NO_x emissions will be held constant while hydrocarbon emissions will be reduced until the standard is attained. Again, the initial run will assume a 50 percent reduction.

3. Other tests - Once the first two tests have been completed, a variety of other tests could be performed to examine spatial factors, time factors (the distribution of emissions during a typical day), mobile vs. stationary source emissions contributions, etc.

The third set of tests remains unspecified because of uncertainties in the amount of time required to prepare and evaluate the first two. If the first two tests are completed in a timely fashion, subsequent tests will be formulated.

SUMMARY OF THE CONTROL STRATEGIES TO BE TESTED

The extreme or limiting case strategies to be tested in step two may be described in terms of both their qualitative themes and the component data sets used. The strategy themes are described as follows:

1. Short Term Baseline (1985) - Air quality in 1985 assuming existing development trends and no new emission control programs.

2. Long Term Baseline (2000) - Air quality in the year 2000, again assuming existing development trends and no new emission control programs beyond those now "on the books".

3. Short Term Technological Improvements (1985) - An assessment of what air quality improvements can reasonably be anticipated through the implementation of a variety of motor vehicle and stationary source emission controls by 1985.

4. Long Term Technological Improvements (2000) - An assessment of air quality improvements to be gained from technology projected to be available for both mobile and stationary sources by the year 2000.

5. Short Term Transportation Controls (1985) - The effect on air quality of a variety of short term transportation controls designed to (a) encourage the use of travel modes other than the single passenger auto (e.g., transit and carpools,) and (b) discourage the use of the automobile. The controls will include both physical facilities such as ramp metering and transit improvements, and pricing schemes such as gasoline and parking surcharges.

6. Combined Short Term Technology and Transportation Controls (1985) - This case tests a maximum control program for 1985 and consists of the combination of cases 3 and 5. The air quality effects of each of the programs separately is not expected to be additive.

7. Slow Growth (2000) - An assessment of the long term effect on air quality of a slower rate of regional population growth. Whether this slower growth rate might occur as a result of declining birth/migration rates or other factors (limited sewage treatment capacity, housing shortages, etc.) is not clear. In any event this case should provide some insight on the growth issue.

8. Compact Land Development (2000) - This case is designed to test the effectiveness of directing future land development toward infill and higher densities within existing urbanized areas. Coupled with this will be assumed transit improvements in existing service areas.

9. Combined Long Term Technology, Slow Growth, and Compact Land Development - This case tests a maximum control program for the year 2000, and consists of the combination of cases 4, 6, and 7.

The data to be supplied by each of the components of the modeling system to quantitatively test these strategies are summarized in Table 1. These data are described as follows:

- Population, Employment, Land Use Models - The ABAG Series III modeling system has produced two base case projections and a compact development projection of population, employment and land use for the region through the year 2000. Base case 1 is a projection of existing trends, and is used in strategy cases 1, 2, 3, 4, 5, and 8. Base case 2 is a lower projection of existing trends using different assumptions about the way the region will grow. This projection is used in strategy case 6. Finally, the compact development case is an alternative to the base cases using the Base Case 2 assumptions about regional growth rates together with different assumptions about where future development will occur. These latter assumptions include higher densities in existing urban areas through infill, redevelopment, and conversion, and a modest shift of job opportunities from the southern Bay Area counties to the northern counties.

- Transportation Model - The transportation modeling analysis will include five different outputs:

  - 1985 baseline travel patterns for strategy cases 1 and 3.

  - 2000 baseline travel patterns for strategy cases 2 and 4.

  - 1985 transportation control strategy for cases 5 and 6.

  - 2000 slow growth travel patterns for case 7.

  - 2000 transit service improvements for cases 8 and 9.

  The transportation control strategy will be devised from the list of transportation control measures presented in Tech. Memo 5.

- Emissions Inventory - A number of different emissions inventories are assembled using the various land use and transportation data, as well as different assumptions about short and long term technological emission control.

TABLE 1. SUMMARY OF STRATEGY CASES FOR AIR QUALITY EVALUATION

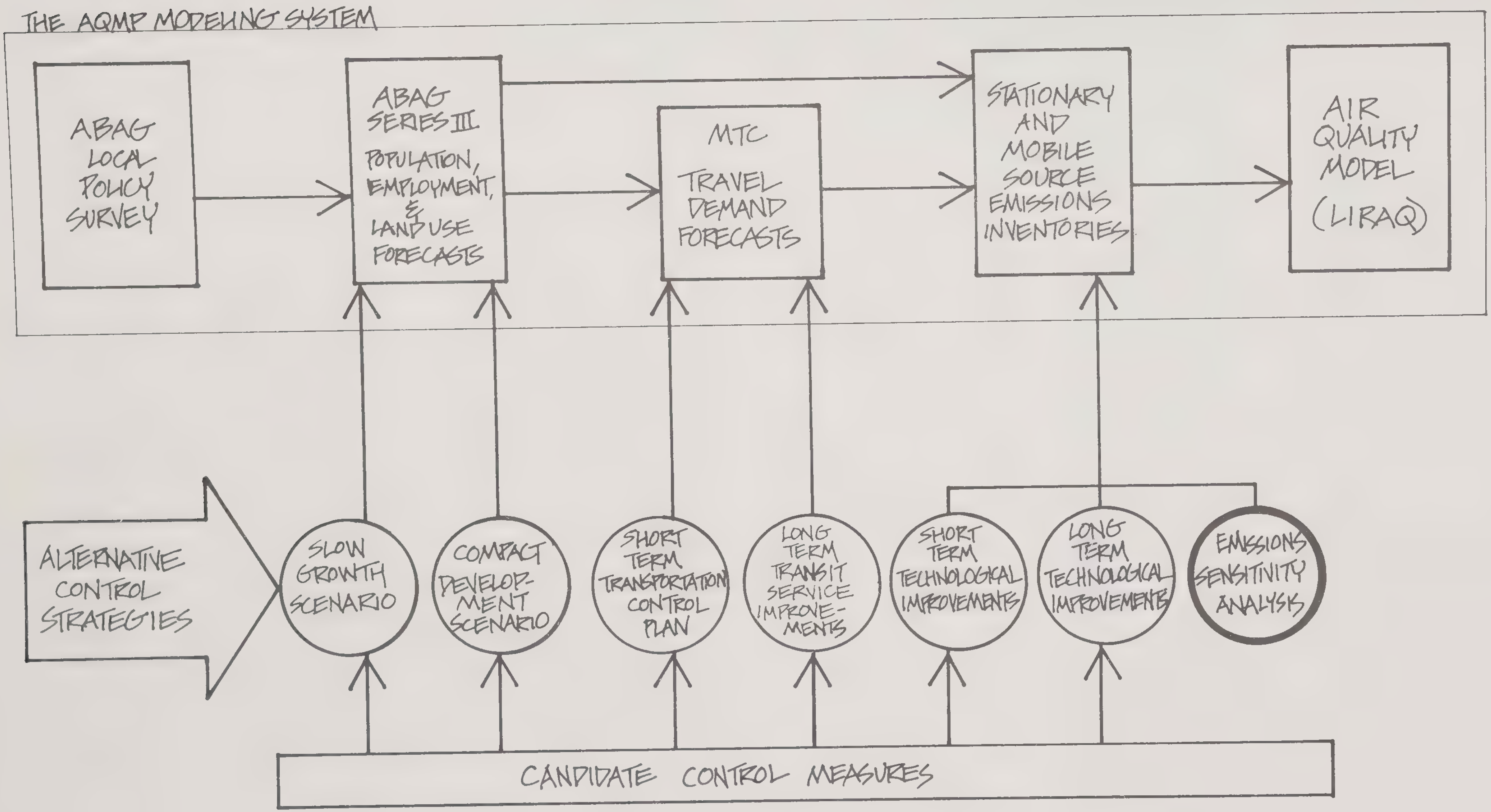
STRATEGY CASE	POPULATION, EMPLOYMENT, LAND USE MODELS	TRANSPORTATION ANALYSIS	EMISSION INVENTORY ASSUMPTION
1. Baseline (1985)	Series III Base Case 1	Baseline travel patterns	Existing control pgms. only
2. Baseline (2000)	Series III Base Case 1	Baseline travel patterns	Existing control pgms. only
3. Short Term Technology only (1985)	Series III Base Case 1	Baseline travel patterns	Short term technology
4. Long Term Technology only (2000)	Series III Base Case 1	Baseline travel patterns	Long term technology
5. Short Term Transportation controls only (1985)	Series III Base Case 1	Transportation control strategy	Existing control pgms. only
6. Maximum strategy for 1985	Series III Base Case 1	Transportation control strategy	Short term technology
7. Slow growth (2000)	Series III Base Case 2	Slow growth travel patterns	Existing control pgms. only
8. Compact land development (2000)	Compact Development Alternative on Series III Base Case 2	Slow growth travel patterns and transit service improvements	Existing control pgms. only
9. Maximum strategy for 2000	Compact Development Alternative on Series III Base Case 2	Slow growth travel patterns and transit service improvements	Long term technology

The cases where additional emission controls will be included are 3, 4, 6, and 9. The short term emission control assumptions will be derived from staff analysis of the list of candidate control measures. The long term emission control assumptions will be derived from the technology forecast to be described in a separate technical memorandum.

As illustrated in Figure 1, these data inputs are thus used to construct emission inventories reflecting each of the strategy cases previously described. The resulting inventories are then input to the air quality modeling analysis to evaluate their effectiveness in improving regional air quality.

FIGURE 1

CONTROL STRATEGY TESTING WITH THE AQMP MODELING SYSTEM



SUMMARY OF THE TECHNOLOGY FORECAST FOR MOTOR VEHICLE EMISSION CONTROL

The Technology Forecast Questionnaire for motor vehicles was designed to explore the long range potential for motor vehicle emission control. The issue was divided into two areas: emission controls for conventional engines and new engine technology. Within each of these areas a variety of technologies for light duty and heavy-duty vehicles were specified (see Attachment A) for consideration by a number of experts who agreed to respond to the questionnaire. For each technology, estimates of the following items were requested:

- Emission rates for hydrocarbons, carbon monoxide, and oxides of nitrogen
- Fuel economy relative to current model year systems
- Retail price and maintenance cost differentials relative to current model year systems
- Time frame for development of the technology through various phases.

A broad range of experts were contacted for participation in the forecast, including regulatory agency representatives, industry representatives, and independent researchers. Of the fifteen questionnaires mailed out only six were completed and returned. This relatively sparse response may be attributed to two factors: first, the sheer number of alternative technologies and the different types of information required for each of them made the questionnaire quite lengthy; and second, the current debate in Congress over pending Clean Air Act Amendments discouraged some panelists from expressing opinions which might be construed as an agency or industry position, and possibly influence the Congressional deliberations. The results obtained from the questionnaires thus largely reflect views from independent researchers.

Finally, it was originally intended that the survey would be conducted in the Delphi format with three rounds of questionnaires and feedback of results between rounds. The slow response to the first round questionnaire and the pressing schedule for development of the Air Quality Maintenance Plan dictated the abandonment of subsequent rounds. Thus there was no opportunity to obtain greater convergence of the results as originally planned.

RESULTS

Responses to the questionnaire for light-duty vehicles have been tabulated and summarized in Figures 1, 2, and 3. In each case, a horizontal bar indicates the range of estimates received, and a circle denotes the

position of the weighted mean estimate. Weighting factors used to compute the weighted mean were based on each respondent's "self-rating" of his familiarity with a given technology (e.g., the estimate from a respondent who rated himself "very familiar" with a given technology was assigned three times the weight of a response rated "unfamiliar"). In the case of emission characteristics for electric and hybrid engine autos, the respondents accepted the estimates published by the Jet Propulsion Laboratory*, which were used as a point of reference for the questionnaire. Therefore, no range has been indicated in these cases. Finally, retail price and ownership cost** differentials for the future technologies (relative to current engine technology) have been plotted on the same graph in Figure 2. Thus, it may be seen that the Brayton engine is forecast to be more expensive to purchase and operate than conventional engines while Stirling engines are forecast to balance increased retail price with decreased ownership cost.

In the case of medium and heavy duty vehicles, the results of the survey are considerably less precise. Due to weaknesses in the questionnaire for these vehicle types and the relatively meager amount of research available, only very generalized observations can be made. These observations are summarized in Figure 4.

PLANNING ASSUMPTIONS

Based on the results of the questionnaire, the following tentative planning assumptions are proposed for air quality evaluation:

1. Emission characteristics for new light-duty vehicles beginning in 1990 will be reduced by fifty percent from the levels originally required by the 1970 Clean Air Act Amendments. In California, this means that the average emission rates over the fifty-thousand mile durability period will be assumed to be 0.2 gms/mi for hydrocarbons, 1.7 gms/mi for carbon monoxide, and 0.2 gms/mi for oxides of nitrogen.

2. Also beginning in 1990, emission rates for new medium and heavy-duty vehicles will be reduced by fifty percent from the rates required for new vehicles by ARB in 1983. For medium-duty vehicles, this means the following: 0.25 gms/mi hydrocarbons, 4.5 gms/mi carbon monoxide, and 0.75 gms/mi. oxides of nitrogen. For heavy duty vehicles, this means: 0.25 gms/BHP-hr hydrocarbons, 12.5 gms/BHP-hr carbon monoxide, and 2.25 gms/BHP-hr of hydrocarbons + oxides of nitrogen.

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*Jet Propulsion Laboratory, "Should We Have a New Engine? -- An Automobile Power Systems Evaluation," August 1975, R. Rhoads Stephenson, Principal Investigator.

**Ownership cost differential is defined as the accumulated difference in cost of operation over a ten year or 100,000 mile period.

FIGURE 1

TECHNOLOGY FOR LIGHT DUTY VEHICLES (AUTOS, PICK-UP, VANS)

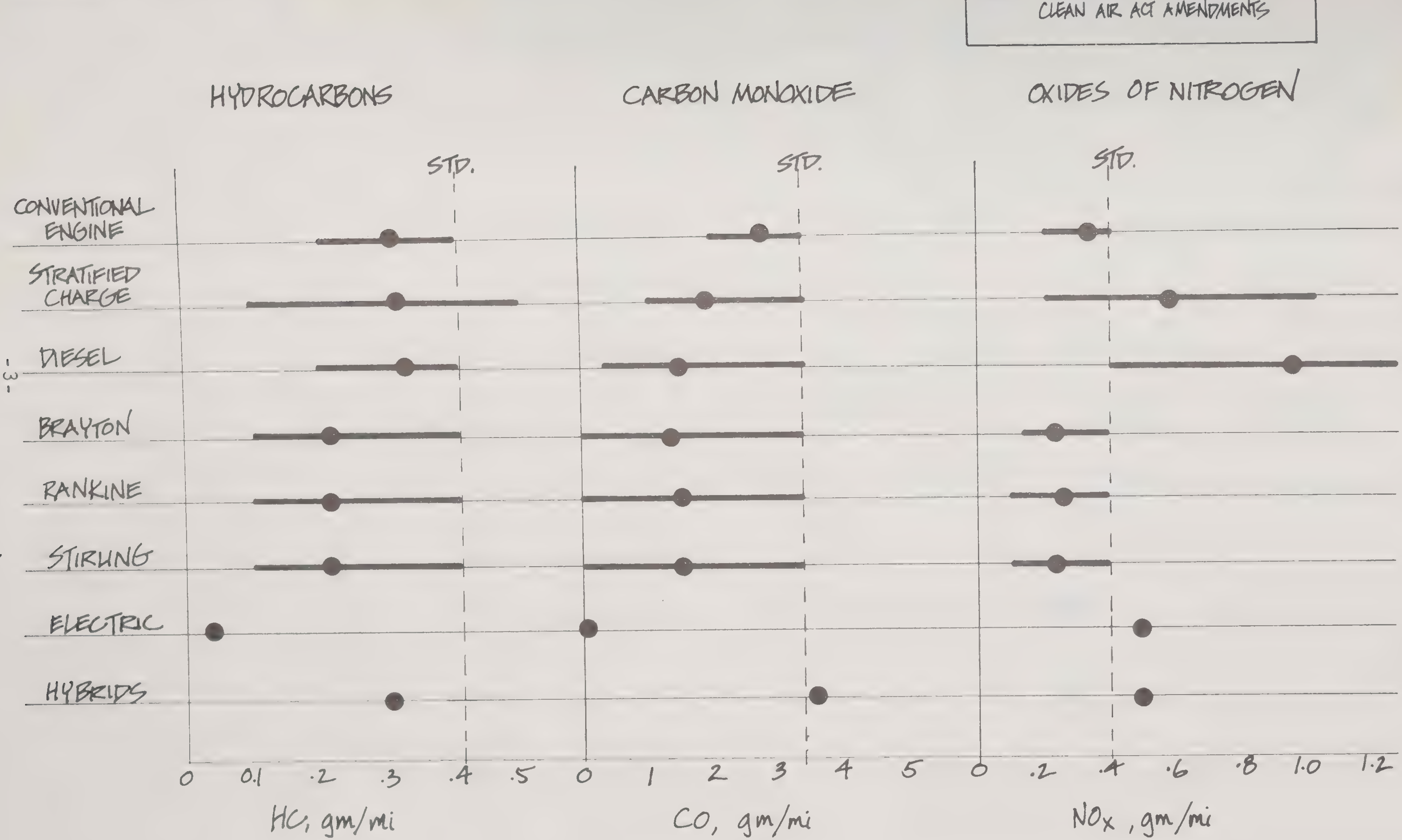
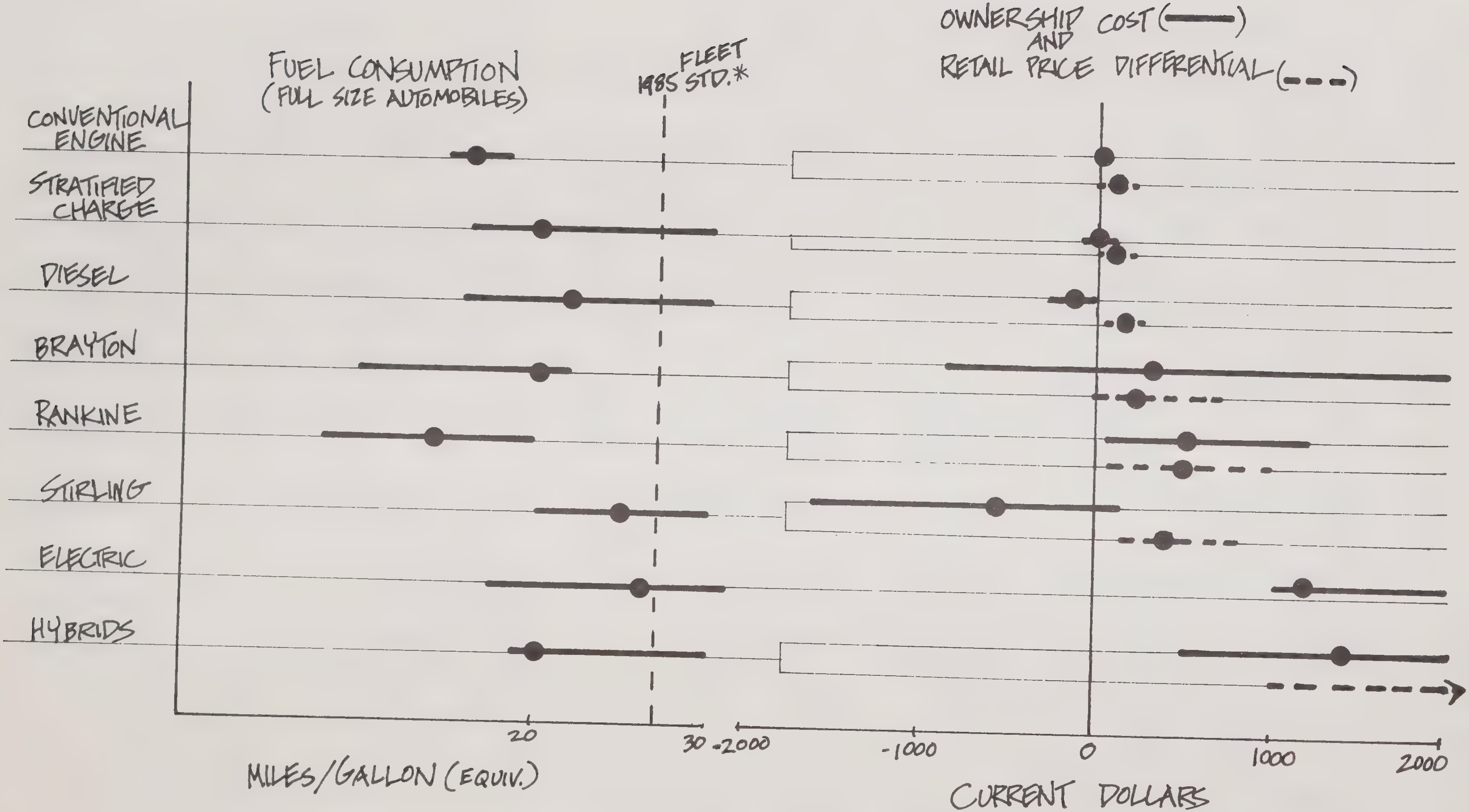


FIGURE 2



* MANDATED BY THE FEDERAL ENERGY POLICY AND CONSERVATION ACT OF 1975

FIGURE 3

TIME FRAME FOR COMMERCIAL INTRODUCTION

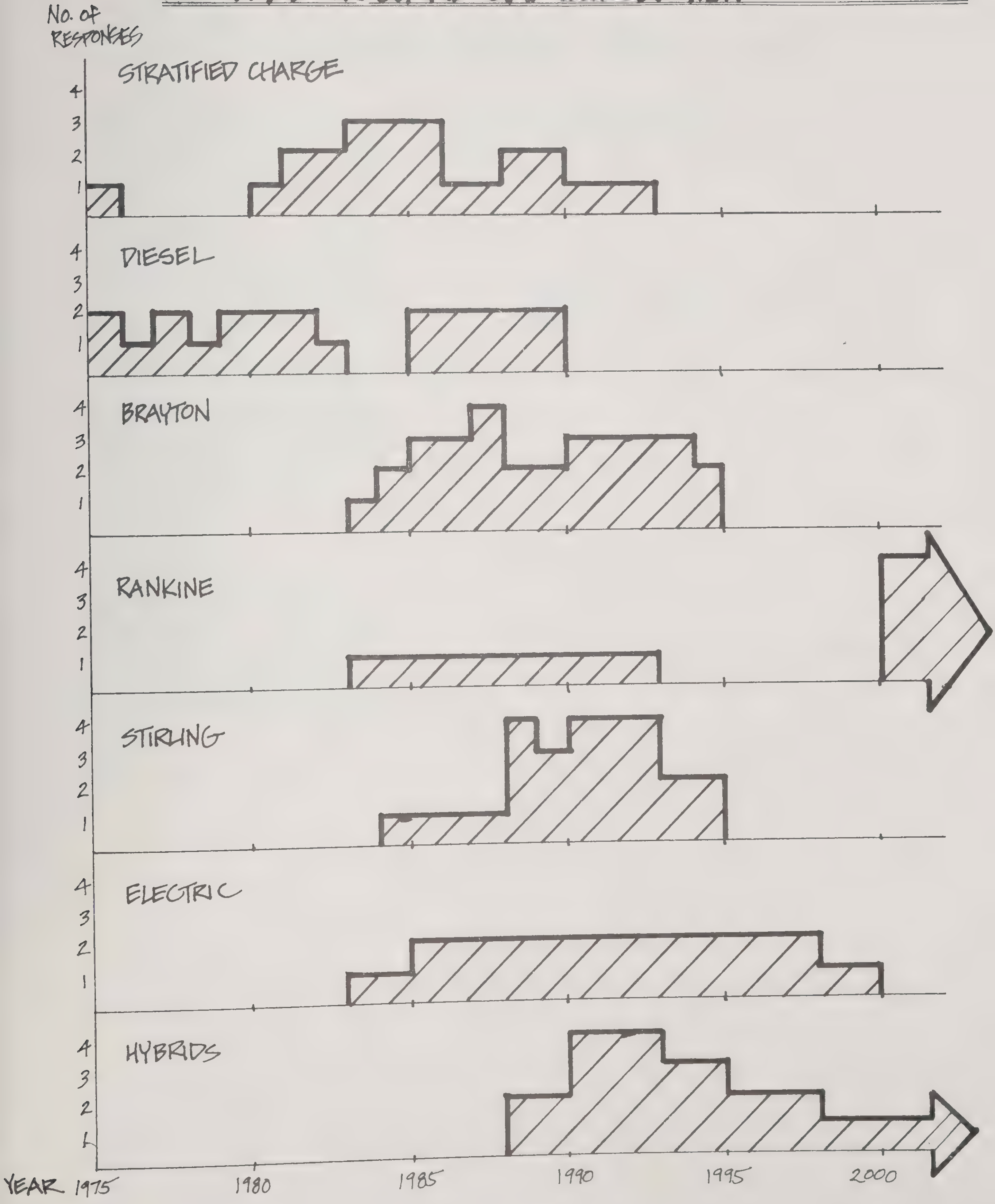


FIGURE 4. TECHNOLOGY FOR MEDIUM AND HEAVY DUTY VEHICLES

Most appropriate alternative Engine types	• Brayton • Stirling
Range of potential emission reductions relative to conventional engines (for both Brayton and Stirling engines).	HC: 0 to 50% CO: 0 to 90% NOx: 50 to 80%
Costs	General consensus that both Brayton and Stirling engines would be cheaper to operate but more expensive to purchase than conventional engines.
Development time frame	These engines may be commercially introduced in the early 1980's (possibly ahead of introduction for light duty vehicles) but in any event are expected before the year 2000.

3. Deterioration rates for all vehicle types will be assumed to be similar, on a percentage basis, to rates currently projected by EPA for conventional vehicles beyond 1982.

These assumptions will be input to a "maximum technology" scenario being developed as one of several long-range control strategy alternatives for consideration by the ABAG Environmental Management Task Force.

ATTACHMENT A --DESCRIPTION OF ALTERNATIVE ENGINE CONFIGURATIONS

- Conventional engine - The engine employed in all but a small percentage of present passenger automobiles: the near-stoichiometric, uniform charge, spark ignited, intermittent-internal combustion engine (also known as the Otto-cycle engine).

- Stratified-charge - These engines are very similar to the conventional Otto type and also exist in both piston and rotary configuration. They too can use exhaust converters to reduce emissions of certain pollutants. The major difference from conventional engines is in the fuel/air charge prepared in such a way that burning starts in a small fuel-rich zone and spreads through the rest of the mixture which is fuel-lean, hence the term "stratified" charge.

- Diesel - an intermittent-combustion engine in which the fuel is ignited by the high temperature of the inducted air after compression. All present engines are piston-type, requiring compression ratios more than twice as great as in Otto-cycle engine, and their fuel may be injected into a small chamber which communicates with the cylinder. To give Otto-equivalent performance, a Diesel engine must have an increased air handling capacity. This is accomplished by means of a turbocharger and wastegate system.

- Brayton - continuous-combustion engine in which the hot gases produced by the burning fuel/air mixture are expanded through a turbine to provide power. Such engines are often called gas turbines. For automobile application, the most suitable designs feature modest intake air compression and recycling of much of the heat left in the gases existing from the turbine.

- Rankine - a continuous-combustion engine wherein heat from the burning fuel/air mixture is transferred to a separate closed system containing a condensible working fluid. The working fluid is vaporized and superheated in a boiler, expanded to produce power, and then condensed back to a liquid for reuse.

- Stirling - a continuous-combustion engine in which heat from the burning fuel/air mixture is transferred to a separate closed system containing a noncondensible working fluid (i.e., a small quantity of high-pressure gas). In producing power, the working fluid is alternately cooled during compression and heated during expansion. The design of this engine also provides for recycling most of the heat energy left in the working gas after expansion.

- Electric - an energy-storage powerplant wherein electric energy from a rechargeable battery is directed to electric motors which, in turn, propel the car.

- Hybrids - a family of powerplants combining a combustion engine with an ancillary electric or other energy-storage system. The objective of these systems is to operate a heat engine of lower horsepower in the range of near-maximum efficiency, while providing power for routine driving chores and delivering a small surplus of power to the energy storage system; the latter then imparts energy to the drive system when bursts of power are called for. Most emphasis to date has been placed upon heat-engine/flywheel hybrids and heat-engine/electric hybrids.

QMP/Tech Memo 9
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July, 1977

SUMMARY OF TECHNOLOGY FORECAST FOR ORGANIC SOLVENT EMISSIONS

Organic solvents appear in paints and coatings used in a wide range of industries that perform surface coating operations e.g. automobile manufacturing, architectural coating, metal decorating and coil coating. They provide the dispersion medium for nonvolatile binders and pigments and they influence many application properties such as consistency, setting rate, drying time and flow. The air quality problem occurs with the evaporation of organics during the surface coating and curing (drying) operations. These subsequently react with nitrogen oxides in the presence of sunlight to form oxidants.

Organic solvent emissions can be reduced by:

- add-on devices that destroy or collect organic vapors for disposal or re-use, respectively
- reformulation of coatings to reduce the organic solvent content
- changes in the coating process that reduce or eliminate the use of organics

While add-on devices have been shown to achieve significant reductions of emissions, their use is limited by their high cost, fuel requirements and feasibility of application.

Regulatory agencies therefore, have turned to coatings reformulations or, new coatings technologies as a means for achieving the greater level of emissions reductions. New coatings in some cases would require or enable new processes that reduce organic emissions.

The purpose of the Technology Forecast Questionnaire on organic solvents was to determine:

- whether new technologies, i.e. new coatings, would achieve significant emissions reductions in the decades to come
- the time frame for these technological developments
- the types of new coatings, their characteristics and problems that are being considered by industry

Twenty-one questionnaires were mailed-out to representatives of industry, regulatory agencies and independent research programs (see attachment A). Of these, approximately fifteen responded to the first two rounds and ten to the third round of questionnaires.

Survey Results

In Rounds I and II of the survey, participants were asked to estimate the organic solvent content of coatings in seventeen user categories. They were asked to give low and high values of the percent organic solvent per gallon of coating, by weight, for the years 1977 and 1980 through 2000 in five year intervals. Round I results and comments were summarized and fed back in the second round for re-consideration, in order to obtain a concensus of opinion.

The results of Round II are summarized in Figures 1 and 2. Figure 1 shows the frequency response curves for 1977, 1985 and 2000 for each user category; Figure 2 shows the modal (most frequent) organic solvent content for 1977, 1985 and 2000. These figures indicate a minimum of 25% reduction in organic solvent content by 1985 in all but 5 categories -- exterior architectural, automotive refinishing, marine, prefinished wood and industrial maintenance. A 50% reduction is predicted for the categories: interior architectural, aircraft/missile metal decorating and coil coating.

Predictions for the year 2000 are even more optimistic, indicating close to 50% or more reductions in all categories except pre-finished wood.

Four coatings/process technologies were identified by survey participants as those most likely to be adopted in the future to yield significant emissions reductions: water-borne, high solids, powder and radiation cure coatings. A description of these coatings is given in attachment B.

The reasons for new developments in coatings technology were stated by panelists as being:

- governmental regulation - much of the impetus in the current years has come from government regulations on air pollution and, to a lesser extent, worker safety and consumer protection.
- consumer preference - water-borne paints have come to dominate the consumer trade-sales market (primarily interior and exterior coatings for houses and buildings) because they are easy to apply, provide easy clean-up and have minimal odor.
- increasing cost of organic solvents raw materials

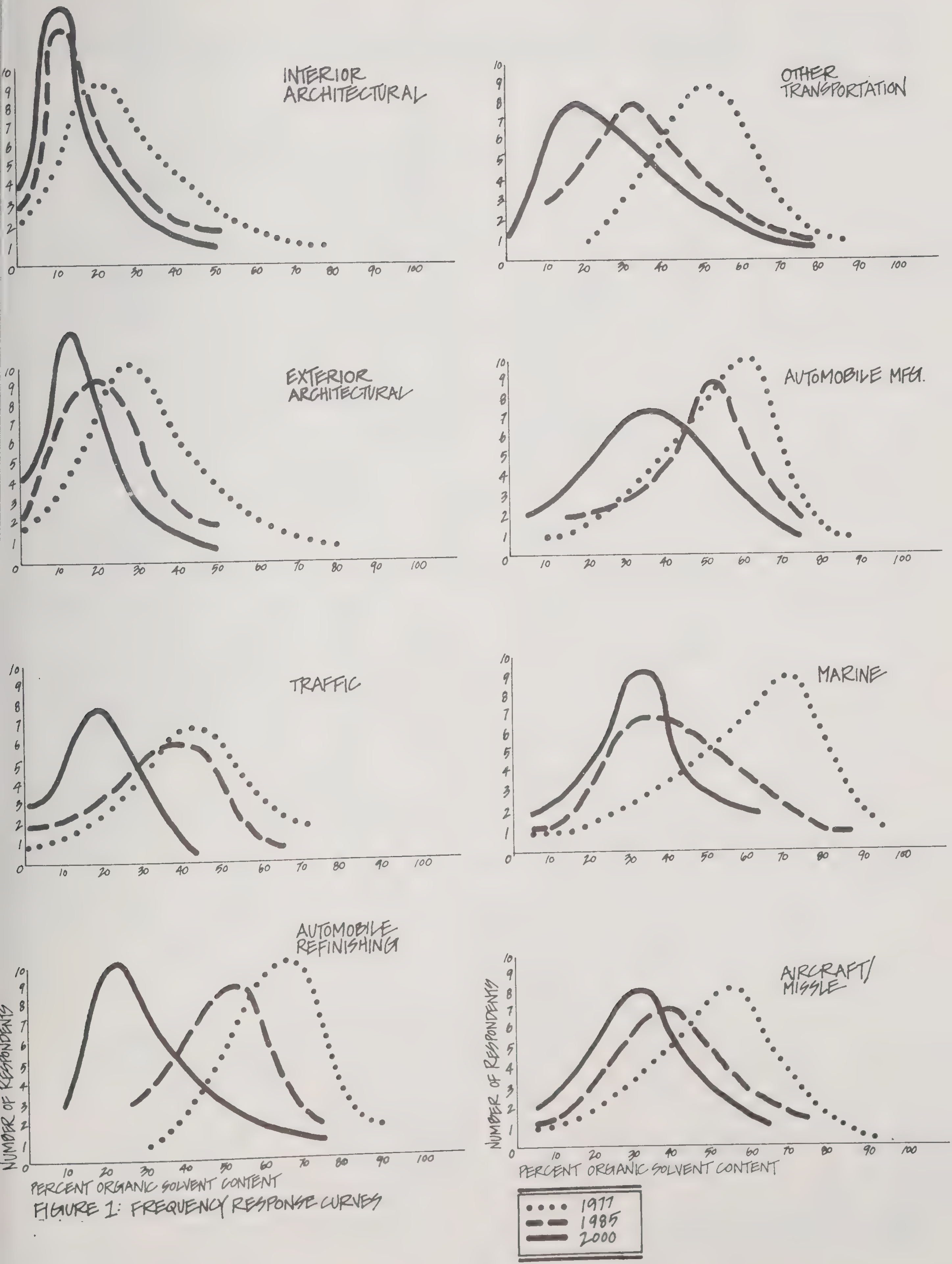


FIGURE 1: FREQUENCY RESPONSE CURVES

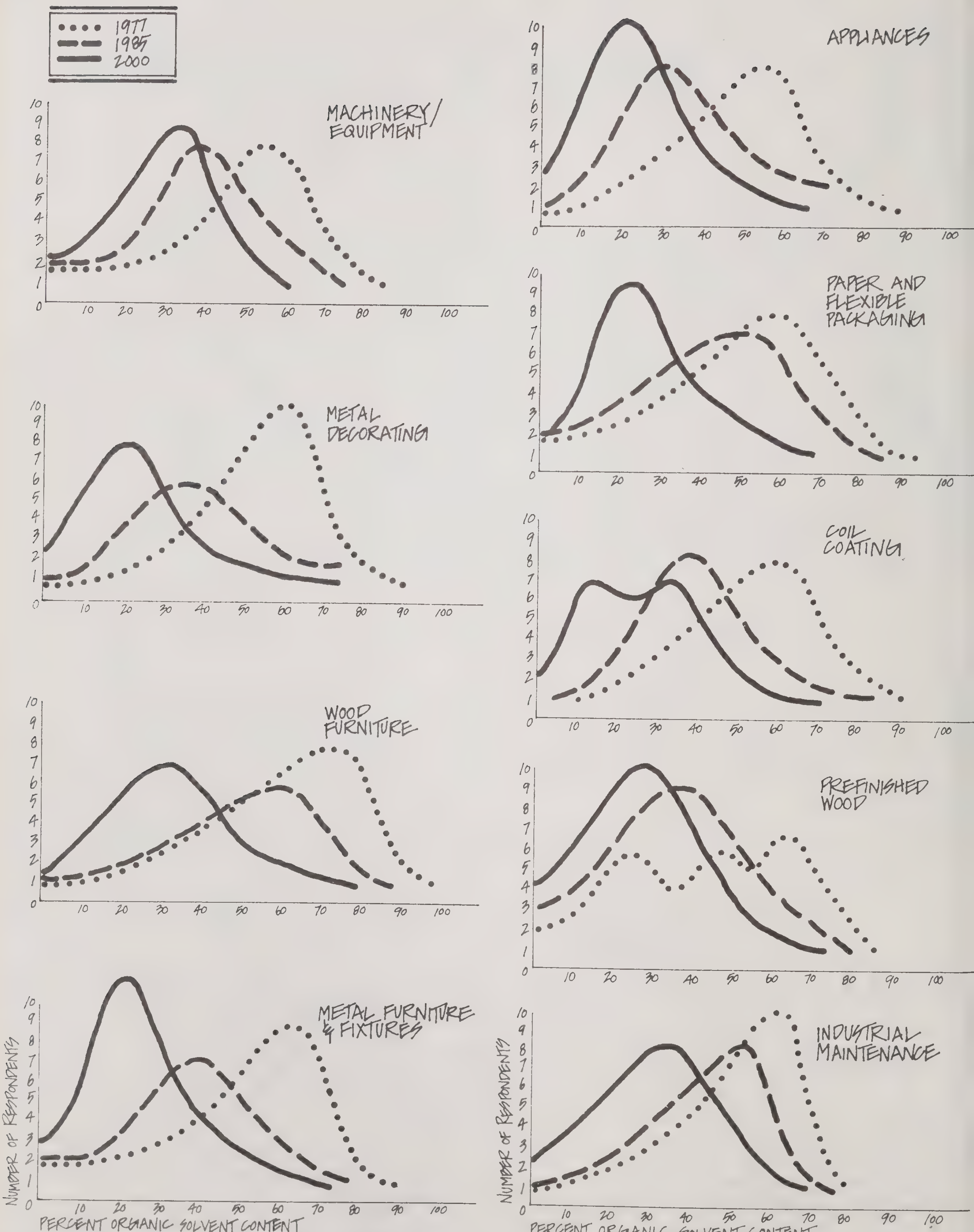
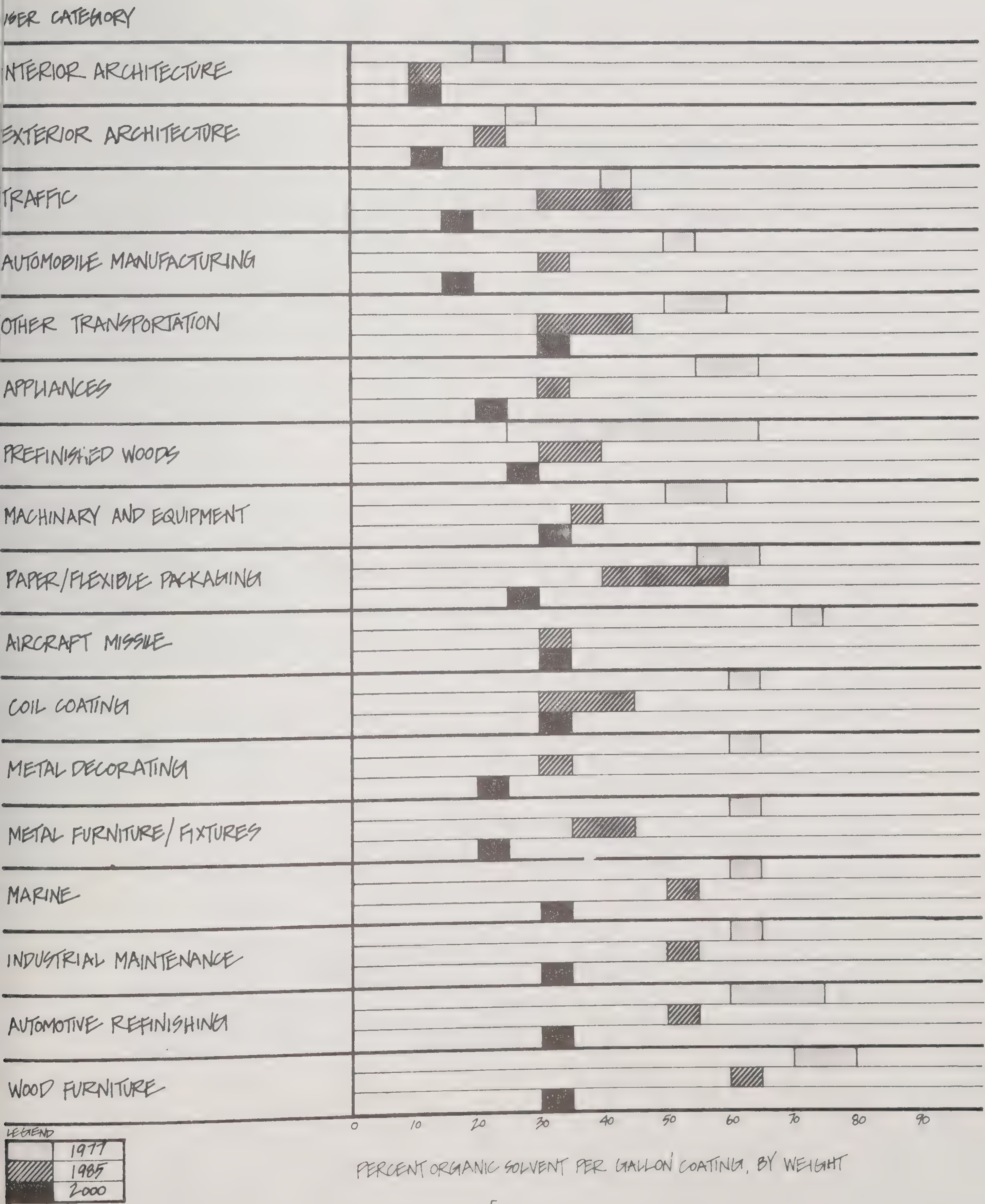


FIGURE 1: FREQUENCY RESPONSE CURVES

FIGURE 2
PROJECTED ORGANIC SOLVENT CONTENT OF COATINGS



- o increasing energy costs - higher energy costs have led to process changes that require less curing and, in some cases, lower solvent content coatings.

In the third and final round of questionnaires, survey participants were asked to comment on the following aspects of implementing new coatings:

- o Financing - the capital, operation, maintenance costs of implementation
- o Physical resources - the effect on solid waste generation, critical land resources, plant space availability, energy consumption and demand
- o Economic - the effect on the price of consumer goods
- o Product Performance - durability, ease of application, etc.
- o Other - e.g. worker health hazards

Their responses are summarized in Figure 3-5.

Conclusions

The results of the survey indicate that considerable progress has been and is being made in efforts to reduce or eliminate the use of organic solvents in coatings. Each of the major candidates for new coatings systems have some problems with adaptation to existing facilities and conformance to product performance specifications. The general feeling of the survey participants, however, is that these problems are not insurmountable.

There will be some beneficial aspects associated with new coatings besides improved organic emissions control. These are improved performance, lower energy costs, reduced use of costly organic raw materials, improved worker conditions.

The increase in cost of consumer goods as a result of new coatings systems is expected to be negligible because 1) the cost of change-over is small or 2) the cost of coatings represents a small part of the total product cost.

The results of the survey will serve as the basis for developing AQMP planning assumptions on future organic emissions (baseline inventories assume only existing control technology and regulations). Listed below are the assumptions that will be made in the planning process, of the percent reductions in organic solvent content in each of the seventeen user categories. If for instance, the survey indicates that the organic

solvent content of interior architectural coatings go from 20% in 1977 to 10% in 2000 then the reduction is assumed to be 50%, in 2000. This reduction percentage will be applied to the baseline emissions (which is based on total sales) to obtain the reduction in organics emissions resulting from improved control technology.

User Category	Organic Solvent Percent Reductions by 2000*
Interior Architectural	50%
Exterior Architectural	50%
Traffic	50%
Automotive Refinishing	70%
Automobile Manufacturing	60%
Marine	50%
Aircraft/Missle	50%
Other Transportation	40%
Machinery/Equipment	40%
Metal Decorating	60%
Wood Furniture	50%
Metal Furniture/Fixtures	60%
Appliances	50%
Paper/Flexible Packaging	50%
Coil Coating	50%
Prefinished Wood	40%
Industrial Maintenance	50%

*Base Year - 1977

NEW COATING TECHNOLOGIES

IMPACT AREAS	WATER-BORNE	HIGH SOLIDS	POWDER	ULTRAVIOLET CURE
FINANCING	• MINIMUM EQUIPMENT CHANGE • EXPENSIVE HUMIDITY AND AIR-CONDITIONING CONTROL REQUIRED • COSTS MAY BE HIGH FOR AUTOMOBILE MANUFACTURING	• MINIMUM EQUIPMENT CHANGES FOR CURING; SOME CHANGE REQUIRED FOR SPRAY APPLICATION	• REQUIRES FLUID BED OR ELECTROSTATIC SPRAY AND HIGH-TEMPERATURE CURING OVEN; CAN BE VERY COSTLY ($1 MILLION)	• UV SOURCE MAY BE EXPENSIVE; CAN NOT BE ADAPTED FROM CONVENTIONAL SYSTEMS. ($20 – 50,000) • ELECTION BEAM SYSTEMS ARE ABOUT $250,000.
PHYSICAL RESOURCES	• WILL STRAIN OXYGENATED SOLVENT AND SYNTHETIC RESIN SUPPLY • DEPRESS VEGETABLE OIL MARKET • HIGH ENERGY CONSUMPTION FOR BAKING	• REQUIRES HALF THE ENERGY CONSUMPTION OF WATER-BORNE COATINGS	• HIGH ENERGY CONSUMPTION FOR BAKING	• LOW ENERGY CONSUMPTION
ENVIRONMENTAL	• SIGNIFICANT REDUCTIONS OF HC EMISSIONS • ADVERSE EFFECT ON WATER QUALITY POSSIBLE	• SIGNIFICANT REDUCTIONS OF HC EMISSIONS	• SIGNIFICANT REDUCTIONS OF HC EMISSIONS • SOME SOLID WASTE DISPOSAL PROBLEMS • DUST IS A WORKER HEALTH HAZARD • POSSIBLE SIGNIFICANT SO_x; NO EMISSIONS FROM CURING APPARATUS	• SIGNIFICANT REDUCTIONS OF HC EMISSIONS • POSSIBLE RADIATION HAZARD • UNPLEASANT ODOR
ECONOMIC	• NOMINAL PRODUCT COST INCREASE • SIGNIFICANT ENERY COSTS FOR TEMPERATURE & HUMIDITY CONTROL; LESS ENERGY REQUIRED FOR CURING • REDUCED EXPENDITURES FOR EXPENSIVE SOLVENTS	• LOWER VENTILATING COSTS • HIGHER PRODUCT COST • SIGNIFICANT OVERSPRAY LOSS • REDUCED EXPENDITURES FOR EXPENSIVE SOLVENTS	• LOW OPERATING COST • HIGH MATERIALS COST (DIFFICULT TO MANUFACTURE) • HIGH ENERGY COSTS • REDUCED EXPENDITURES FOR EXPENSIVE SOLVENTS	• OVERALL ENERGY COSTS MAY BE LOWER (2000 WATTS/LINEAR INCH) • ENABLES FAST PRODUCTION SCHEDULING
PRODUCT PERFORMANCE & QUALITY	• POOR FLOW, PENETRATION ADHESION & CORROSION PROTECTION • EASY CLEAN-UP • PERFORMANCE IS IMPROVING CONTINUOUSLY • SHOULD NOT BE APPLIED BELOW 50°F	• DIFFICULT TO CONTROL FLOW AND FILM THICKNESS • LESS DURABLE FILM • SIMILAR TO SOLVENT SYSTEMS	• EXCELLENT FOR DURABILITY AND TO HIDE SURFACE DEFECTS • DIFFICULT TO MATCH OR SWITCH COLORS • DIFFICULT TO RETOUCH OR APPLY TO IRREGULAR SHAPES	• SUITABLE FOR FLAT OR ALMOST FLAT SURFACES • FAST DRYING • GOOD PERFORMANCE
OTHER	• REDUCED FIRE HAZARD & INSURANCE RATES • GREATER STORAGE STABILITY PROBLEMS • TOXICITY MAY BE CONCERN	• HIGH SOLIDS PREDICTIONS (I.E. 80%) MAY BE OPTIMISTIC	• LOW FIRE HAZARD • LIMITED APPLICATIONS • CAN'T APPLY THIN FILMS • QUALITY CONTROL IS DIFFICULT	• HAS GOOD FUTURE IN LIMITED APPLICATIONS

Figure 4. Costs of New Coatings

Coating	Application	Capital Cost	Operating Cost
Water-borne	electrodeposition	$.5M for small tank < 1000 gal. 1.0M major install > 65,000 gal. (automobile) (1971 costs)	10¢-30¢/1000 sq.ft. 17¢/1000 sq.ft. average (1971 costs)
	electrostatic spray	$3000 or less to change from solvent to water system	
	flow coating line	"	
High solids*		low	1.0-3.2¢/sq.ft./Mil. for 40M sq.ft/yr.
Powder	fluidized-bed	$40,000-250,000 complete system	low
	electrostatic spray	$250,000 or more double booth, multi-guns +twin collection system	
Ultra-violet		$20-50,000 for complete system	$10-15/hour (requires one man per line)

*high solids, in this case represents higher solids coatings 70-75% solids.

M = million

Figure 5. Energy Requirements of New Coatings

	Solvent	Water Base	High Solids	Powder
Bake Temperature	325°F.	350°F.	350°F.	375°F.
BTUH Requirement (MBTU)				
Ware (1)	351.0	378.0	378.0	405.0
Oven Make-up (2)	1,043.0	997.1	483.4	306.1
Spray Booth (2)	990.0	990.0	990.0	--
Conveyor Heat-up (3)	81.0	83.2	88.2	94.5
Insulation Loss (4)	243.5	276.4	276.4	291.2
TOTAL BTUH	2,709.5	2,729.7	2,216.0	1,096.0
COMPARISON	100	101	82	40

BTUH = British Thermal Units per Hour

Source: Levinson, "Powder Coat", Jrnl. Paint Technology, Vol. 44, No. 570, p. 38-56.

ATTACHMENT A

List of Survey Participants

Roblen Resins

Chevron Research Company

San Diego Air Pollution Control District

Shell Oil Company

Bay Area Air Pollution Control District

AMSCO

C.H. Kline Company

David Litter Labs.

Cal Ink, a Division of Flint Ink Incorporated

PPG Industries, Inc.

California Air Resources Board

Glidden-Durkee, Division of SCM

Southern California Air Pollution Control District

NAPKO Corporation

Springborn Laboratories

KVB, Inc.

Polymers and Coatings Department
University of Southern Mississippi

Polymers and Coatings Department
North Dakota State University

Environmental Protection Agency - Region IX

Tenneco Chemicals, Inc.

Dow Chemical Company

ATTACHMENT B

Definition of Terms

Trade-Sales Paints - Trade sales paints are standard shelf goods produced for inventory and sold to builders, contractors, industrial and commercial users, government and the general public. These products serve primarily as exterior and interior coatings for houses and buildings, automotive refinishing and traffic paints.

Chemical Coatings - Chemical coatings are industrial product finishes which are produced to user specification and sold to other manufacturers for factory application on such items as automobiles, appliances, furniture, metal containers and aircraft. Unlike trade sales paints there are few standard product lines.

Water-borne Coatings - Water-borne coatings (or systems) are finishes containing at least 80% of their volatile content as water with the balance as exempt (exempt is defined by Rule 66) organic solvent. They can be applied by dip, flow, electrodeposition or coil coating.

Electrodeposition - Water-borne coatings in industrial applications are mostly applied by electrodeposition where the object is attached to an electrode and dipped into a tank filled with water-dispersed paint. Charged particles of paint are deposited on the object when an electric current is applied.

High-Solids Coatings - High solids coatings contain 80% or more solids, by volume.

Ultra-Violet Cure System - Ultra-violet cure systems are one of two principal curing systems that employ radiation - the other being electron-beam. Coatings for ultra-violet cure systems are really in the high-solids category as they are composed of 100% solids (no solvents).

Powder Coatings - Powder coatings contain 100% solids and no solvents. They are applied with fluidized bed processes or by electrostatic spray. They are most suitable for small metal parts with intricate shapes, which require only one color.

Fluidized Bed Processes - The fluidized bed process uses bed of powdered fusible coating maintained in turbulent suspension by an upward flow of air. When an object is preheated above the melting point of the powder and emmersed in the bed, the particles adhere to the object and fuse to form a continuous film.

Electrostatic Spray - Particles of the powder coating are given charge at the nozzle of a spray gun, generating an electrostatic field between the gun the object to be coated, which is grounded. The particles are attracted to the substrate where they are cured by heat to a homogeneous film.

AQMP/Tech Memo 10
I. Kan

July 1977

SUMMARY OF RESULTS

TECHNOLOGY FORECAST QUESTIONNAIRE
COMBUSTION SOURCES

The Technology Forecast Questionnaire was designed to determine the impact of future technological developments on combustion source emissions. By polling a panel of experts using the Delphi technique, it was hoped that a consensus opinion could be obtained on a wide range of new and commercially untested technologies that might have significant impacts on the nature of air quality problems in the decades to come. While technological solutions have large public appeal because they involve minimum disruption of established institutions and lifestyles, they often involve long lead times between conceptualization and commercial usage, and they involve very high costs. This survey effort was designed to identify a realistic time frame for when new control techniques would become available in order to gain a perspective on the need for other types of controls. The results of the survey were planned to 1) help define best available control technologies (BACT) by 1985 and 2000 and 2) determine the upper bound of future emissions and air quality estimates.

The first round of questionnaires (originally three were planned) covered the following areas:

- baseline emissions for five combustion units: commercial boilers, refinery heater, industrial firetube boiler, industrial watertube boiler, utility boiler
- reduction of SOx and NOx and particulate emissions for each of the above units
- pace of technological development
- control costs

The control technologies that were evaluated are listed in Table 1.

While the rate of response to Round 1 was satisfactory -- fifteen mailed back out of eighteen -- few of those surveyed were able to complete more than 25% of the questionnaire. None of the participants were familar or had expertise in all the controls or in all the types of units. The results of the survey are described in the following section.

TABLE 1

CONTROL TECHNOLOGIES

SO_x

FLUE GAS DESULFURIZATION
- limestone process
- lime process
- magnesia process
- sodium process
- catalytic oxidation

ALTERNATIVE CLEAN FUEL FROM COAL
- low/medium BTU gas
- synthetic oil
- desulfurized coal

DESULFURIZATION OF PETROLEUM

PARTICULATE:

- electrostatic precipitator
- mechanical collector
- bag filterhouse
- wet scrubber
- fuel additive
- opacity monitoring/ burner controls

NO_x:

COMBUSTION MODIFICATION
- low excess air
- staged combustion
- flue gas recirculation
- reduced air preheat
- burner design modifications

FLUE GAS TREATMENT
- selective catalytic reduction
- selective non-catalytic reduction (ammonia)
- oxidation/scrubbing

ALTERNATE CLEAN FUEL FROM COAL
- low/medium BTU gas
- synthetic oil
- desulfurized coal

FUEL ADDITIVES

FUEL DENITRIFICATION
(pretreatment of fuel to remove nitrogen compounds)

CATALYTIC COMBUSTION

QUESTIONNAIRE RESULTS

The results of the survey are summarized in Attachment A. Respondents were requested to rate themselves as very familiar, moderately familiar or unfamiliar with each control technology. The values of responses show the range of values given by those who indicated that they were moderately or very familiar with the subjects in question.

The following observations were made on the survey results:

- The wide range of technologies being studied and developed for combustion emissions control is so extensive that it is difficult for a single group or individual to have expertise in all of them. Typically, research efforts concentrate on one aspect of control a particular class of combustion unit, a single pollutant, engineering feasibility, economic feasibility, commercial application, etc.

- A very wide range of emissions reduction potential were reported (e.g. 20-95% for flue gas desulfurization on desulfurization on utility boilers). This could be attributable to the fact that control efficiencies for new technologies are based on prototype, idealized operating conditions; actual operational performance may vary significantly. Thus, engineers who have experience in implementing new controls tend to be more pessimistic than researchers.

- Up-to-date cost data are difficult to obtain. Although cost information exists (and was cited by a few of the respondents) in the literature, they are often two, three or more years old or are presented in a variety of non-standardized formats. Some cost information of control equipment is known by manufacturers but are of a proprietary nature.

- There existed some question as to whether the percentage reductions cited by respondents were applicable to baseline or uncontrolled emissions levels (although the instructions specified reductions over baseline emissions).

- The wide range of projected control efficiencies indicated that there are considerable operational problems with the proposed technologies and that actual emissions reductions will be lower than those projected by research efforts.

- Implementation of NOx controls in new units are considerably less difficult and costly than existing units.

- Flue gas desulfurization costs appear to have risen 200 to 300 per cent from the last comprehensive and definitive cost study performed by McGlamery and Torstrick in 1975.

o The technologies which are predicted to be available by 1985 for widespread commercial use are:

flue gas desulfurization
- limestone process
- lime process
- sodium process

desulfurization of petroleum to .25% sulfur

combustion modification
- staged combustion
- low excess air
- flue gas recirculation
- burner modifications

flue gas denitrification
- selective non-catalytic reduction with ammonia

fuel denitrification

o Additional technologies which are predicted to be available for widespread commercial use by the year 2000 Are:

alternative clean fuels
- low/medium BTU gas
- oil from coal
- desulfurized coal

desulfurization of petroleum to .1% sulfur

flue gas denitrification
- selected catalytic oxidation

TECHNOLOGY WORKSHOP

In view of the problems encountered with using the questionnaire format, a one-day workshop was convened to discuss further the status of combustion control technology. Participants of the workshop (see Attachment B for attendance list) were asked to review the results of Round I and attempt to narrow the range of response where possible. Thier comments and opinions are summarized in attachment A.

Planning Assumptions

Based on Round I results and workshop comments, the following tentative planning assumptions are proposed for the air quality evaluation:

1. Flue gas desulfurization (FGD) processes are able to yield 80% or more reductions of SOx emissions over uncontrolled levels for utility and large industrial boilers (assuming .5% sulfur content in fuels).

2. Desulfurization of petroleum to .25% sulfur content is commercially feasible now.

3. FGD controls for smaller industrial and commercial boilers are not cost-effective at present levels of fuel prices and supplies. FGD becomes economically attractive when fuel is high in sulfur content and low in price. However non-utility boilers are not equipped to burn dirtier fuels (problems of corrosion, etc.)

4. Combustion modification techniques for reducing NOx emissions from existing industrial and commercial boilers do not appear to be technically or economically feasible. However, 10-20% reductions have been demonstrated through improved maintenance and improved fuel atomization via emulsifiers.

5 Alternate clean fuels appear to be most promising for industrial and commercial boilers which would not be able to switch satisfactorily to dirtier fuels. These technologies appear to become technically and economically feasible in the late 1980's-1990's as low sulfur fuels become scarce and, consequently, more expensive.

6. Flue gas treatment for NOx control appears to be feasible by 2000 only for large industrial and utility boilers. It would yield 50-90% control efficiency, depending on the process.

ATTACHMENT A - SURVEY RESULTS

QUESTION 1 BASELINE EMISSION FACTORS

Emission control technology will be examined for five combustion categories, identified as major sources of NO_x, SO_x and particulate emissions in the Bay Area. These categories are listed below:

MAJOR COMBUSTION CATEGORIES:

Commercial Boiler (for space heating)
Refinery heater
Industrial Boiler-.3-10 mmbtu/hr; firetube
Industrial Boiler-10-250 mmbtu/hr; watertube
Utility Boiler->250 mmbtu/hr

In this question, a baseline emissions level is established for each combustion category in order to provide a base from which to calculate control effectiveness.

INSTRUCTIONS: We would like you to critically review the baseline emission factors and where you disagree, correct them appropriately. These factors represent present emissions characteristics with state-of-the-art controls and current emissions regulations.

SOURCE DESCRIPTION | POLLUTANT[1]

EQUIPMENT TYPE	FUEL	SO_x (LB/MMBTU)		NO_x (LB/MMBTU)		PARTICULATE (LB/MMBTU)	
COMMERCIAL BOILER	GAS			.008		.001	
REFINERY HEATER	GAS			.22		.002	
	REFINERY GAS[2]	.001	.0026-.4	.22	.05-.5	.002	.001-.02
	RESIDUAL[3]	.533	.25-.56	.460	.2-.5	.133	.05-.15
	COKE[4]	1.26	.7-2.0	.72		.18	
INDUSTRIAL BOILER-FIRETUBE	DISTILLATE ~~RESIDUAL~~	.523	.05-.56	.40	.1-.2	.153	.01-.06
INDUSTRIAL BOILER-WATERTUBE	RESIDUAL	.523	.25-.56	.40	.25-.5	.153	.05-.2
	COAL[5]	1.20	1.2	.70	.70	.10	.10
UTILITY BOILER	RESIDUAL	.523	.523	.700	.70	.053	.053
	COAL[5]	1.20	1.80	.70	.70	.10	.10

1) SOURCE: AP-42
2) .016% SULFUR IN REFINERY GAS; 1035 BTU/CU.FT
3) .5% SULFUR IN RESIDUAL OIL; 150,000 BTU/GAL
4) 35 LB SO_x/TON COKE, 20 LB NO_x/TON COKE, 5 LB PART/TON COKE; 1000 MBTU PER 36 TONS COKE
5) NEW SOURCE PERFORMANCE STANDARDS

QUESTION **2** EMISSION REDUCTION POTENTIAL

In this question we assess the potential emissions reduction of a wide range of control technologies for the combustion source categories given in Question 1. The technologies are shown below, along with some specific processes and techniques which appear promising. It is recognized that stationary source control technology for SO_x and NO_x are in varying stages of development with uncertain commercial futures. Thus, combustion and emission characteristics may not have been established on a fully operational scale. In many cases, emissions reduction can only be accurately determined on a case-by-case basis, depending on the particular operating mode of the equipment. Nevertheless, for planning purposes, we again make the same assumptions on combustion equipment as in Question 1 in order to evaluate a control's relative effectiveness.

INSTRUCTIONS: We would like you to give low and high estimates of emissions reduction potential for the appropriate combinations of technology and source category. Your estimates should be in the form of percent reduction over the baseline emissions developed in Question 1 (as corrected by you). For example, combustion modification techniques can achieve 30-50% reduction in NO_x emissions from utility boilers.

Please also indicate your degree of familiarity with each technology, i.e., very familiar, moderately familiar, unfamiliar. You are encouraged to comment on your estimates, add to the list of technologies or specify promising processes for a technology.

PARTICULATES

EMISSIONS REDUCTION POTENTIAL (%)

SOURCE	COMMERCIAL BOILER	REFINERY HEATER				INDUSTRIAL BOILER-FIRE TUBE	INDUSTRIAL BOILER-WATERTUBE		UTILITY BOILERS		* LEVEL OF FAMILIARITY	COMMENT **
FUEL	GAS	GAS	REFINERY GAS	RESIDUAL	COKE	RESIDUAL	RESIDUAL	COAL	RESIDUAL	COAL		
BASELINE EMISSIONS (FILL IN)												Baseline emissions assume 90% + control
CONTROL: ELECTROSTATIC PRECIPITATOR									0-30	0-45		
MECHANICAL COLLECTORS									0	0		
BAG FILTERHOUSES									0-60	0-70		for fine particulate control
WET SCRUBBERS									0-30	0-30		
FUEL ADDITIVES									0-20	0-20		
OPACITY MONITORING/ BURNER CONTROLS									10-20			
VISCOSITY CONTROL									10			
OTHER (FILL IN)									30	30		

* 1 - VERY
2 - MODERATELY
3 - UNFAMILIAR

** USE THE BACK OF THIS PAGE FOR ADDITIONAL COMMENTS.

QUESTION 3 PACE OF TECHNOLOGICAL DEVELOPMENT

New technological concepts pass through several stages of research and development before successful commercial applications can be realized. The first is that of scientific feasibility (I) where the concept is experimentally verified. The second is that of engineering feasibility (II) where an operating prototype verifies that a concept will in fact function as intended. The next step of commercial development (III) tests the concept against competitive alternatives and demonstrates economic feasibility. Finally, a technically and economically proven desirable alternative is ready for widespread adoption (IV) to be integrated physically and operationally into the entire system. Typically, the lag time or accession from one stage to another takes many years. Sometimes, scientific discoveries, governmental regulations, new technological insights and changing economic conditions will speed up this process and make feasible, processes which formerly appeared to be infeasible.

INSTRUCTIONS: In this question, we would like you to 1) identify specific and most promising process(es)/technique(s) under each broadly named technology; 2) indicate for each process or technology the stages of development on the time scale provided as follows:

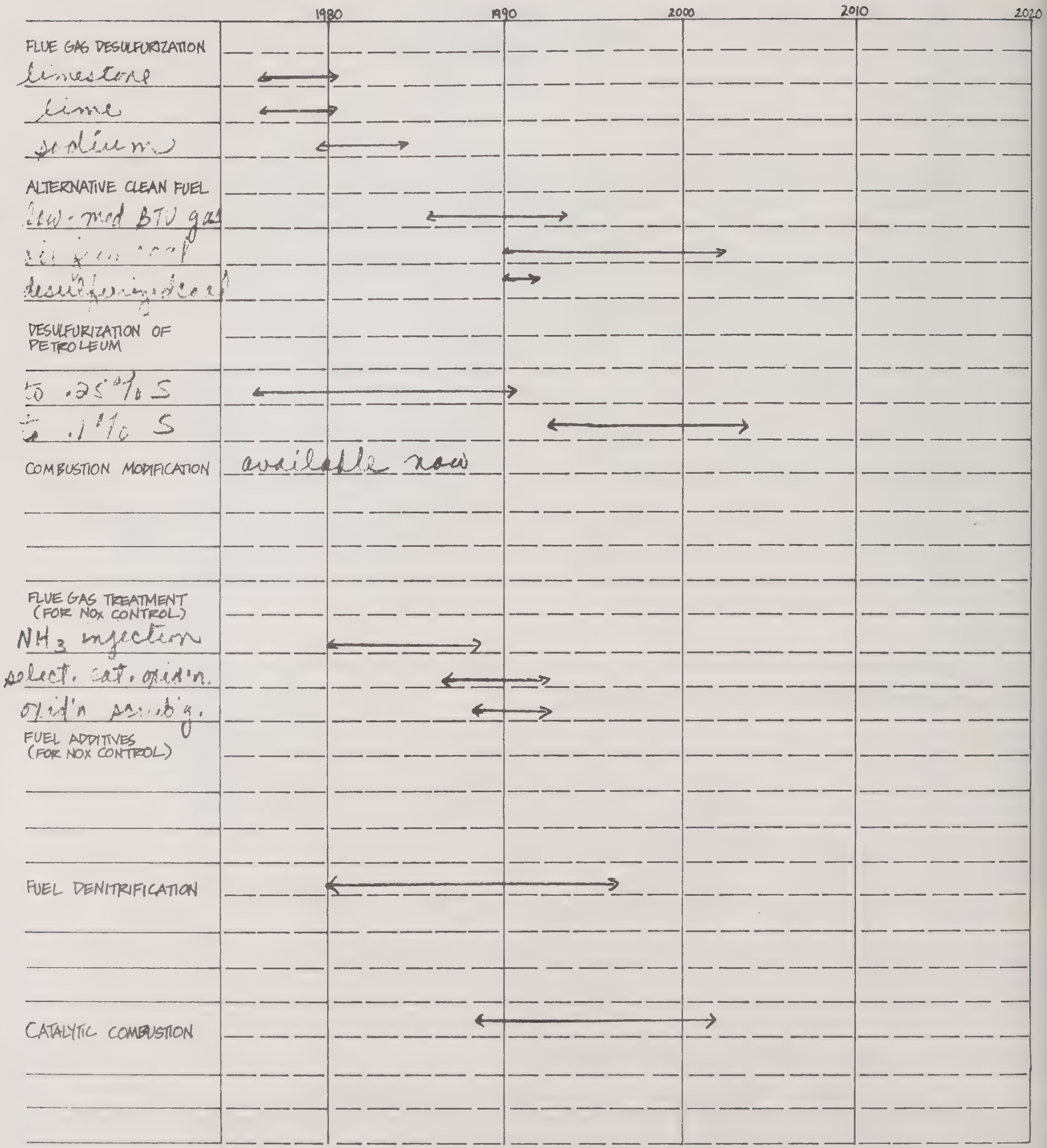
Let II represent engineering feasibility is demonstrated

III represent commercial feasibility is demonstrated

IV represent widespread adoption is achieved

It is assumed that the scientific feasibility (Stage I) of all of these processes has been demonstrated.

PACE OF TECHNOLOGICAL DEVELOPMENT



⟷ time frame for availability of technology for widespread commercial adoption

QUESTION 4 CONTROL TECHNOLOGY COSTS

Determining control technology costs is made difficult by the dearth of commercial applications, fast changing economic trends and uncertain political climate. Nevertheless, for planning purposes we require some estimates of control capital and operating cost to evaluate the relative cost-effectiveness of controls. An appendix to this questionnaire containing cost data derived from current literature, is provided for your reference.

INSTRUCTIONS: We will require cost information in various formats, depending on the particular control technology considered. Specific instructions are given for each technology. In all cases, give low and high estimates of the appropriate cost items. Estimates should reflect the cost differential directly attributable to control implementation. For instance, the capital cost of a new boiler with combustion modifications for NO_x control should be the increase in boiler cost due to the modifications.

Where capital costs are requested, include in your estimate, the cost of design engineering. Annual costs should include maintenance, energy and monitoring costs, taxes and insurance. Do not include annualized capital cost in the operating cost.

State costs in 1977 dollars. If this is not possible, state the base period for which your estimates are given.

You are encouraged to explain the basis of your estimates, as necessary, in the Comments column.

FLUE GAS DESULFURIZATION COSTS[1]

SOURCE:

Process	Efficiency[2]	Cost[3]	INDUSTRIAL BOILER - WATERTUBE				UTILITY BOILER						Level of Familiarity[4]	Comments[5]
		MW					< 200	200-400	400-800	800-1000	800-1000	800-1000		
		Fuel	OIL		COAL		OIL	OIL	OIL	OIL	OIL	COAL		
		Status	RETROFIT	NEW	RETROFIT	NEW	RETROFIT	RETROFIT	RETROFIT	RETROFIT	NEW	NEW		
LIMESTONE	50 %	C												
		O												
	70 %	C					175-215	70-185	55-170	50-150	35-115	50-120		
		O					3.7	3.6	3.5	3.4	2.7	3.2		
	90 %	C					185-230	70-195	55-180	50-160	35-120	50-130		
		O					4.0	3.9-4.8	3.3-5.6	3.-5.	3.-5	3.-5.		
LIME	50 %	C												
		O												
	70 %	C					150-210	135-180	125-165	115-145	80-110	85-115		
		O					3.9	3.8	3.7	3.6	2.9	3.4		
	90 %	C					180-225	140-190	135-175	120-155	85-130	90-125		
		O					4.2	4.1	4.0	3.9	3.4	3.7		
MAGNESIA	50 %	C												
		O												
	70 %	C												
		O												
	90 %	C												
		O												
SODIUM	50 %	C												
		O												
	70 %	C					150-290	150-260	150-235	150-210	125-150	125-190		
		O					1.8-8.5	1.8-5.0	1.8-7.5	1.8-7.0	1.6-6.5	1.6-7.0		
	90 %	C					260-330	230-250	190-260	180-230	140-190	145-200		
		O					1.0	9.5	9.0	9.0	8.5	8.0		
CATALYTIC OXIDATION	50 %	C												
		O												
	70 %	C												
		O												
	90 %	C												
		O												

1) STATE CAPITAL COST IN $/KW; OPERATING IN MILLS/KWH; DO NOT INCLUDE ANNUAL CAPITAL IN OPERATING COST
2) % OF EMISSIONS REDUCTION
3) C-CAPITAL O-OPERATING
4) 1-VERY 2-MODERATELY 3-UNFAMILIAR
5)
USE THE BACK OF THIS PAGE FOR ADDITIONAL COMMENTS

COMBUSTION MODIFICATION COSTS[1]

SOURCE UTILITY BOILERS

CONTROL	EFFICIENCY[2]	COST[3]	MW: <200 FUEL: OIL STATUS: RETROFIT	MW: 200-400 FUEL: OIL STATUS: RETROFIT	MW: 400-800 FUEL: OIL STATUS: RETROFIT	MW: 800-1000 FUEL: OIL STATUS: RETROFIT	MW: 800-1000 FUEL: OIL STATUS: NEW	MW: 800-1000 FUEL: COAL STATUS: NEW	LEVEL OF FAMILIARITY[4]	COMMENTS[5]
LOW EXCESS AIR	30%	C	.53	.33	.16-.21	.12				1974 costs from
		O								EPA
	50%	C								
		O								
	70%	C								
		O								
STAGED COMBUSTION	30%	C								
		O								
	50%	C								
		O								
	70%	C								
		O								
FLUE GAS RECIRCULATION + staged combustion	30%	C		8.7-11.8		8.5				1975 costs from PG&E
		O								average = $10/KW
	50%	C								
		O								
	70%	C								
		O								
REDUCED AIR PREHEAT	30%	C								
		O								
	50%	C								
		O								
	70%	C								
		O								
BURNER DESIGN MODIFICATIONS	30%	C								
		O								
	50%	C								
		O								
	70%	C								
		O								

1) GIVE CAPITAL COSTS IN $/KW, OPERATING COST IN MILLS/KWH; DO NOT INCLUDE ANNUALIZED CAPITAL IN OPERATING COST.
2) % EMISSIONS REDUCTION
3) C-CAPITAL O OPERATING
4) 1-VERY 2-MODERATELY 3-UNFAMILIAR.
5) USE THE BACK OF THIS PAGE FOR ADDITIONAL COMMENTS

COMBUSTION MODIFICATION COSTS[1]

SOURCE[2]

CONTROL[4]	COST	COMMERCIAL BOILER: GAS	REFINERY HEATER: GAS	REFINERY HEATER: REFINERY GAS	REFINERY HEATER: RESIDUAL	REFINERY HEATER: COKE	INDUSTRIAL BOILER-FIRE TUBE: RESIDUAL	INDUSTRIAL BOILER-WATERTUBE: RESIDUAL	INDUSTRIAL BOILER-WATERTUBE: COAL	3 LEVEL OF FAMILIARITY	COMMENTS USE THE BACK OF THIS PAGE FOR ADDITIONAL COMMENTS
LOW EXCESS AIR	CAPITAL (000's)	5-8	15-20	15-20	20-30	25-35	[illegible]	20-30	25-35		NEW
	OPERATING (000's)	2-4	2-10	2-10	2-10	2-10	2-4	2-20	2-20		
	LIFE										
STAGED COMBUSTION	CAPITAL (000's)	4-6	10-15	10-15	10-15	20-30	4-6	10-15	20-30		NEW
		8-12	20-30	20-30	30-50	35-55	8-12	30-50	35-55		RETROFIT
	OPERATING (000's)										
	LIFE										
FLUE GAS RECIRCULATION	CAPITAL (000's)	5-10	30-50	30-50	30-50	30-50	5-10	30-50	30-50		NEW
		30-50	70-120	70-120	70-120	70-120	30-50	70-120	70-120		RETROFIT
	OPERATING										
	LIFE										
REDUCED AIR PREHEAT	CAPITAL (000's)		5-10	5-10	5-10	5-10	NA	5-10	5-10		NEW
			10-20	10-20	10-20	10-20	NA	10-20	10-20		RETROFIT
	OPERATING										
	LIFE										
BURNER DESIGN MODIFICATIONS	CAPITAL (000's)		10-15	10-15	10-15	20-30	NA	10-15	20-30		MINOR
			60-100	60-100	60-100	80-120		60-100	80-120		MAJOR
	OPERATING										
	LIFE										

1) DO NOT INCLUDE ANNUALIZED CAPITAL COST IN OPERATING COST.
2) PROVIDE COST ESTIMATES FOR NEW UNITS. INDICATE IN THE COMMENTS COLUMN, THE DIFFERENTIAL IN COST (eg. PERCENT OF STATED COST) WHICH WOULD BE REQUIRED FOR RETROFIT OF EXISTING UNITS.
3) 1 - VERY 2 - MODERATELY 3 - UNFAMILIAR
4) STATE THE CONTROL'S EFFICIENCY IN THE COMMENTS SECTION.

FUEL MODIFICATION COSTS

CONTROL	$ / MMBTU	LEVEL OF FAMILIARITY *	COMMENTS**
DESULFURIZATION OF PETROLEUM			
• TO .25 % S	$ .25-.61		
• TO .1 % S	$ .25-.68		
ALTERNATE CLEAN FUELS			
• LO/MED BTU GAS	$ 5.+		for Bay Area, assumes stripped coal
• SYNTHETIC OIL FROM COAL	$ .50		"
• DESULFURIZED COAL			
DENITRIFIED FUEL	$ 2.5		
FUEL ~~ADDITIVES~~ (~~FOR~~ NOx CONTROL)			

* 1-VERY
2-MODERATELY
3-UNFAMILIAR

** USE THE BACK OF THIS PAGE FOR ADDITIONAL COMMENTS.

Attachment B - List of Technology Workshop Participants
July 19, 1977

Alan Goodley	California Air Resources Board
Ron Friesen	California Air Resources Board
Don Bartz	KVB, Incorporated
Don Christensen	PG & E
Robert Hosemann	PG & E
James Quinn	PG & E
Roger Staha	PG & E
Herb Johnson	Bay Area Air Pollution Control District
James Tomich	Bay Area Air Pollution Control District
Don Teixeira	Electric Power Research Institute
Bill Loscutoff	California Air Resources Board
Gary Leach	California Air Resources Board
Eugene Leong	Association of Bay Area Governments
Ron Wada	Association of Bay Area Governments
Irene Kan	Association of Bay Area Governments

FUEL MODIFICATION COSTS

CONTROL	$/MMBTU	LEVEL OF FAMILIARITY *	COMMENTS**
DESULFURIZATION OF PETROLEUM			
• TO .25 % S	$,25-,61		
• TO .1 % S	$ .25-,68		
ALTERNATE CLEAN FUELS			
• LO/MED BTU GAS	$ 5.+		for Bay Area, assumes stripped coal
• SYNTHETIC OIL FROM COAL	$,50		"
• DESULFURIZED COAL			
DENITRIFIED FUEL	$ 2.5		
FUEL ~~ADDITIVES~~ (~~FOR~~ NOx CONTROL)			

* 1-VERY
2-MODERATELY
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Irene Kan	Association of Bay Area Governments

AQMP/Tech Memo 11
R. Wada

August 1977

PRESENT AND PROJECTED AIR POLLUTANT EMISSIONS IN THE SAN FRANCISCO BAY REGION

This memorandum is a summary of present and projected emissions of five major air contaminants for the San Francisco Bay region. The purpose of the emissions inventory is to identify each significant source of pollutants contributing to the air quality problems of the region. In some cases, it is possible to identify a single category of sources as being the major contributor to a given problem (e.g., carbon monoxide from motor vehicles or sulfur dioxide from fuel combustion in industrial and utility boilers). In other cases such as for photochemical oxidant, no single category of sources can be identified as the root of the problem. By identifying the most significant sources in each case, the emissions inventory provides direction for efforts to control emissions and minimize the problems they cause. Thus, the inventory is a crucial prerequisite to the development of any plan to improve air quality.

In order to develop a long range plan to improve air quality, it is necessary to know not only what current emission levels are, but what future emission levels will be. As described in AQMP Tech Memo 2 (December 1976), estimates of current emissions from each category of sources are combined with estimates of the rate of growth in each case and the expected effects of any control programs which may be in the process of implementation.

The wide variety of sources and pollutants which must be covered makes the compilation of an accurate inventory a very tedious task. In some cases, the basic information needed is of poor quality. In other cases, different information sources will provide conflicting data which must be evaluated. On the whol , however, the inventories produced provide a reasonable basis for control strategy development.

SUMMARY OF THE INVENTORY AND CONTROL STRATEGY IMPLICATIONS

Emission inventories have been compiled for 1975, 1985, and the year 2000, and are summarized in Tables 1, 2, and 3. They are also shown in graphic form in Figures 1 through 5. Estimates of stationary source and aircraft emissions were made by the Bay Area Air Pollution

Control District,[1] while motor vehicle emissions estimates were made through the joint efforts of ABAG, MTC, and the California Air Resources Board.[2]

For hydrocarbons, the most significant source categories are organic compounds evaporation (otherwise known as organic solvents) and both light and heavy duty motor vehicles. Each of these source categories have previously been the target of control efforts, and it is evident that further controls will be necessary if significant air quality improvement is to be made. Total hydrocarbon emissions are projected to decrease somewhat by 1985 due to the implementation of controls now on the books, but to rise back to the 1975 level by the year 2000.

For oxides of nitrogen, the principal source categories are stationary source fuel combustion, and light and heavy duty motor vehicles. Efforts to control motor vehicle NO_x emissions have been controversial in recent years while stationary source NO_x control has been limited to only the largest sources. The problem in pursuing NO_x control is that NO_x alone is not a problem in the Bay Area. It is a contributor to the photochemical oxidant problem in the region, but its precise role has not been well defined to date. NO_x emissions are projected to remain at a relatively constant level over the 25 year planning time frame. By 1985, the expected increase in stationary source NO_x emissions due to increased use of fuel oil will be offset by additional motor vehicle NO_x control. By 2000, increasing usage of nuclear fuels for electric power have been assumed to offset increased NO_x emissions in other source categories.[3]

In the case of carbon monoxide, light and heavy duty motor vehicles are by far the most significant sources. Unlike hydrocarbon and NO_x emissions, CO emissions are projected to be substantially <u>greater</u> in the year 2000 than they are in 1975. The principal causes of this result are the overall growth in vehicle activity over the 25 year period, and the expected deterioration of current vehicle emission control technology.

Sulfur dioxide emissions are due primarily to stationary source fuel combustion, and petroleum refining and chemical operations. A substantial increase in SO_2 emissions is projected to occur by 1985, due primarily to the progressively limited supplies of natural gas and the expected switch to fuel oil and coal for combustion processes. SO_2 emissions decrease slightly by the year 2000 due to an assumed switch of a portion of PG&E's electric power generating capacity to nuclear plants. (See footnote 3).

---

1 Bay Area Air Pollution Control District, "Method of Projection", May 31, 1977 (draft), and "Emission Inventory Summary Report", August 18, 1976.

2 AQMP Tech Memo 12, "Baseline Motor Vehicle Emissions Inventory: Methodology and Results", August 1977 (In print).

3 The effects of <u>no</u> nuclear capacity by the year 2000 will be evaluated as a sensitivity test on the baseline inventory.

Finally, emissions of suspended particulate matter are produced from many diverse sources, with no single source or sources contributing a large share. Emissions for this pollutant are projected to increase steadily between 1975 and 2000. A significant unknown is the contribution to particulates from windblown dust and secondary organics (photochemical aerosol). Until these unknowns are better defined, it will be difficult to properly interpret the emission inventory for particulates.

TABLE 1. 1975 EMISSIONS BY MAJOR SOURCE CATEGORY

MAJOR SOURCE CATEGORY	EMISSIONS (TONS/DAY)				
	HC	NO_x	CO	SO_2	Part.
Petroleum Refining	25.2	5.9	-	39.0	2.5
Chemical	5.5	3.1	37.3	84.6	4.9
Other Industrial/Commercial	10.2	2.5	21.7	5.9	75.3
Petroleum Refinery Evaporation	46.0	-	-	-	-
Gasoline Distribution	60.4	-	-	-	-
Other Organic Coumpounds Evaporation (Organic Solvents)	311.1	-	-	-	-
Combustion of Fuels	8.1	196.0	17.5	43.7	16.3
Burning of Materials	19.8	1.4	58.2	0.3	12.9
Off-Highway Mobile Sources	45.0	59.4	277.7	25.8	5.2
Aircraft	19.6	13.5	54.5	1.3	9.0
Light-duty Automobiles	340.1	231.7	2,357.0	7.4	27.8
Other Motor Vehicles	132.2	167.8	1,507.0	11.3	15.2
TOTAL (TONS/DAY)	1,023	731	4,331	219	169

TABLE 2. 1985 EMISSIONS BY MAJOR SOURCE CATEGORY

MAJOR SOURCE CATEGORY	EMISSIONS (TONS/DAY) HC	NOx	CO	SO2	Part.
Petroleum Refining	41.0	15.2	-	67.5	4.4
Chemical	5.6	2.9	37.5	89.1	5.2
Other Industrial/Commercial	11.1	2.7	24.0	6.5	80.8
Petroleum Refinery Evaporation	50.0	-	-	-	-
Gasoline Distribution	27.1	-	-	-	-
Other Organic Coumpounds Evaporation (Organic Solvents)	344.8	-	-	-	-
Combustion of Fuels	11.5	321.1	21.3	213.9	34.5
Burning of Materials	22.2	1.5	62.7	0.3	13.9
Off-Highway Mobile Sources	50.3	73.7	322.6	30.9	6.3
Aircraft	20.2	19.6	69.9	1.6	11.4
Light-duty Automobiles	117	89.3	1,768.7	9.7	18.8
Other Motor Vehicles	96	165.8	1,699.3	15.0	16.3
TOTAL (TONS/DAY)	797	692	4,006	435	192

TABLE 3. 2000 EMISSIONS BY MAJOR SOURCE CATEGORY

MAJOR SOURCE CATEGORY	EMISSIONS (TONS/DAY)				
	HC	NO_x	CO	SO_2	Part.
Petroleum Refining	55.4	20.0	-	88.9	5.8
Chemical	6.	3.9	37.5	119.8	6.1
Other Industrial/Commercial	12.7	3.1	24.0	7.4	90.5
Petroleum Refinery Evaporation	52.1	-	-	-	-
Gasoline Distribution	28.2	-	-	-	-
Other Organic Coumpounds Evaporation (Organic Solvents)	493.4	-	-	-	-
Combustion of Fuels	15.0	279.8	25.7	129.9	30.7
Burning of Materials	23.6	1.7	69.7	0.4	22.5
Off-Highway Mobile Sources	75.4	94.1	389.3	31.1	7.8
Aircraft	27.8	32.7	106.3	2.5	19.4
Light-duty Automobiles	160.6	77.1	2,505.0	13.2	22.3
Other Motor Vehicles	107.1	208.4	2,505.0	20.4	19.8
TOTAL (TONS/DAY)	1,058	721	5,663	414	225

FIGURE 1

HYDROCARBON EMISSION TRENDS

SAN FRANCISCO BAY REGION

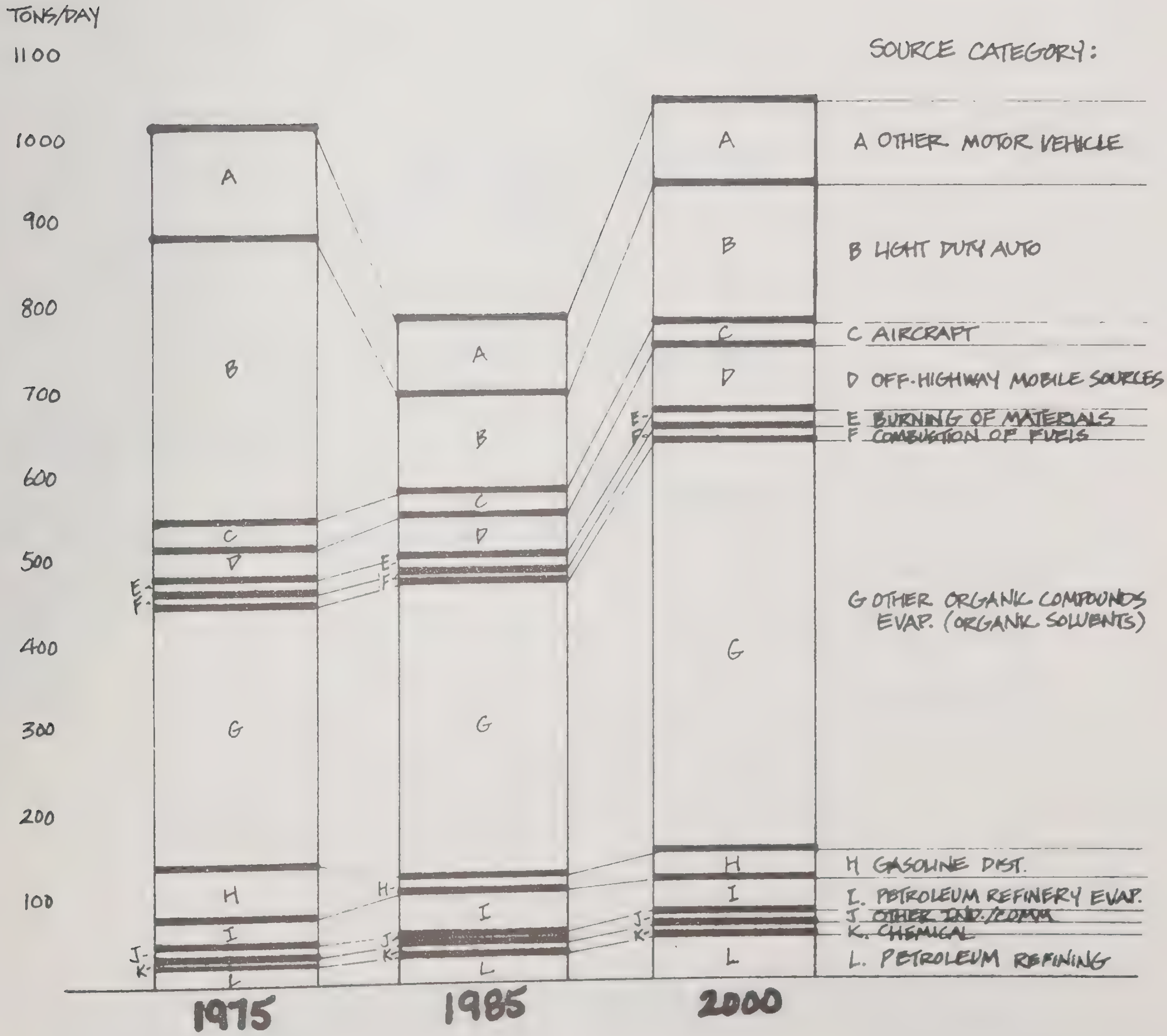


FIGURE 2

NITROGEN OXIDES EMISSION TRENDS

SAN FRANCISCO BAY REGION

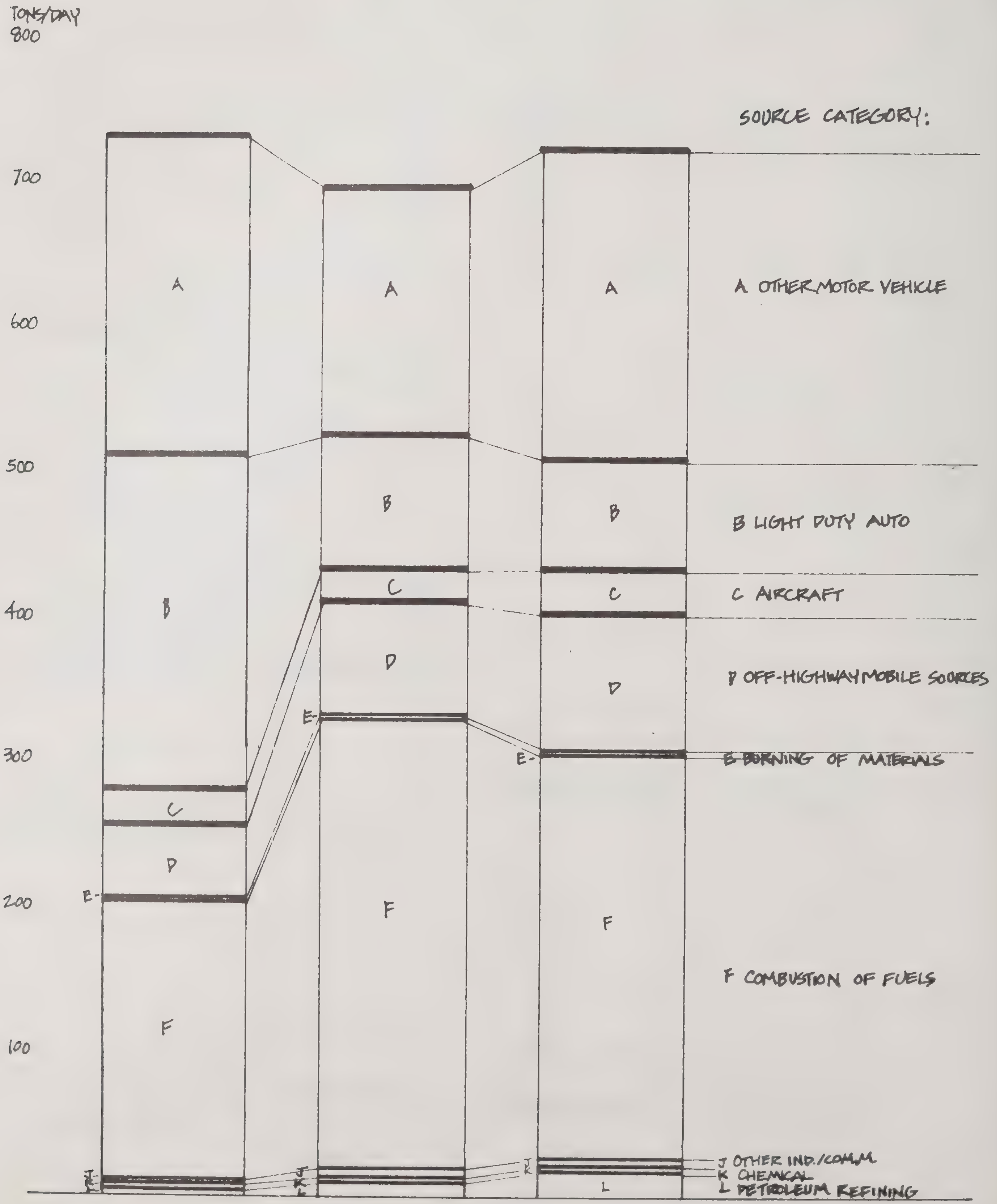


FIGURE 3

CARBON MONOXIDE (CO) EMISSION TRENDS

SAN FRANCISCO BAY REGION

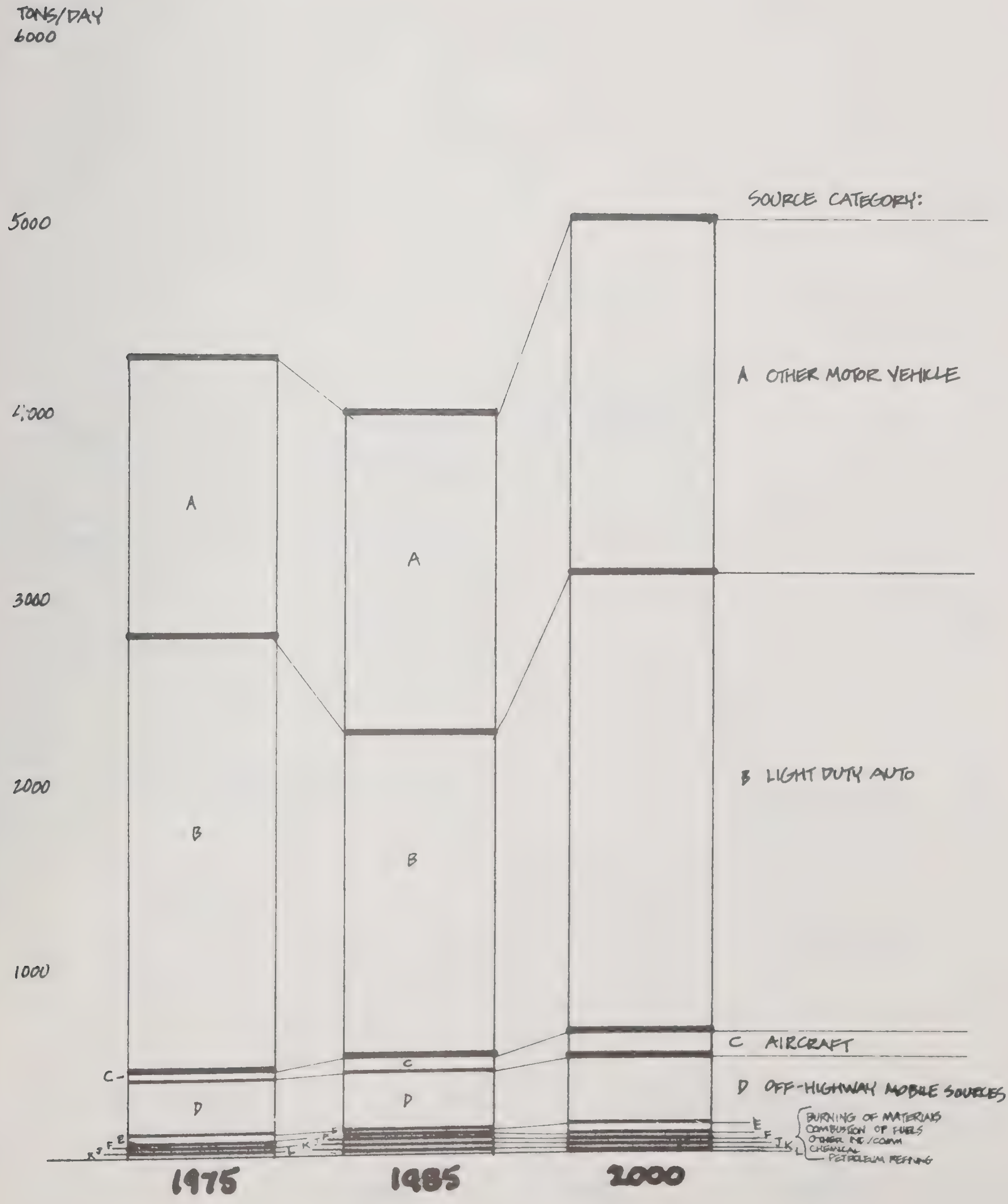


FIGURE 4

SULFUR DIOXIDE EMISSION TRENDS

SAN FRANCISCO BAY REGION

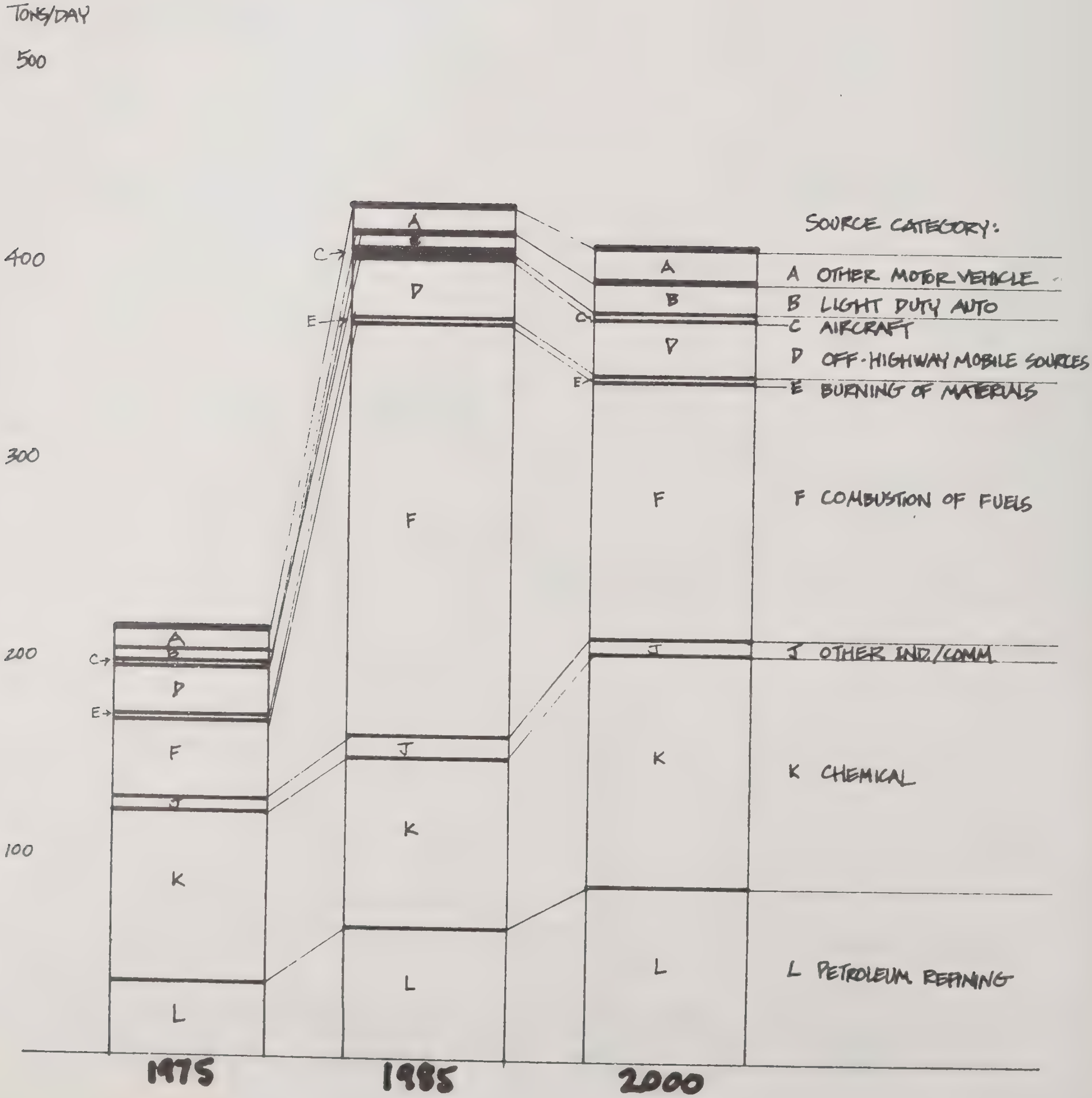
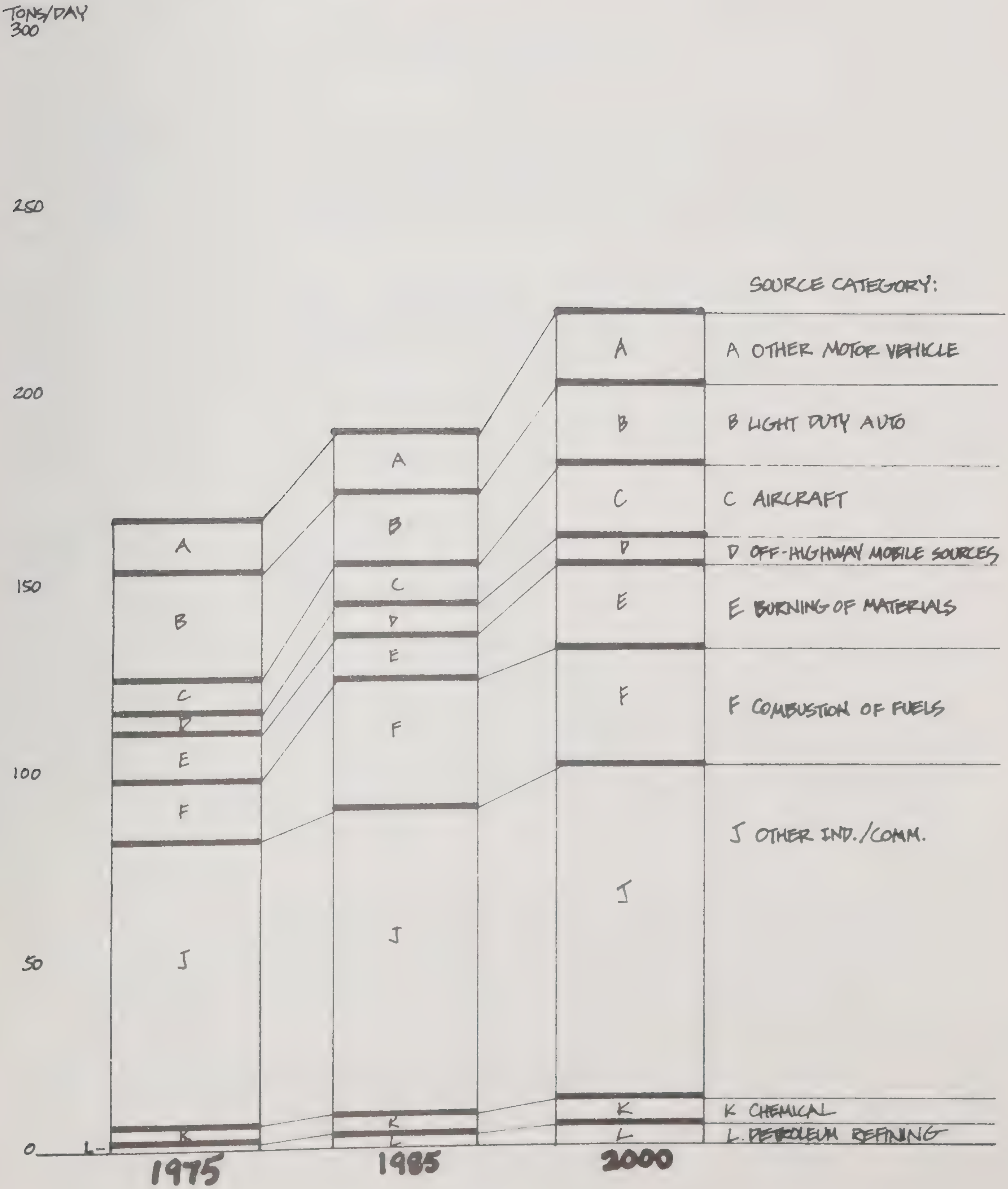


FIGURE 5

PARTICULATES EMISSION TRENDS

SAN FRANCISCO BAY REGION



AQMP/Tech Memo 12
R. Wada
I. Kan

August 1977

BASELINE MOTOR VEHICLE EMISSION INVENTORY: METHODOLOGY AND RESULTS

This memorandum describes the methodology employed for calculating present and projected emissions of pollutants from motor vehicles in the San Francisco Bay Region. In addition, the results of the calculations are summarized for baseline conditions (i.e., no further emission controls or transportation controls assumed).

In selecting the particular methodologies and assumptions the objective was to strike a balance between accuracy and available time and data resources. Thus, those factors which most significantly affect motor vehicle emissions, and for which a reasonable combination of data and assumptions were available, were included. These factors include new emission standards, speed correction factors, ambient temperature correction factors, separate accounting of trip end related emissions, and the very latest available emission factors developed by EPA[1] and provided by ARB.[2]

Conversely, a variety of other factors which have a minor effect on emissions have not been included in the calculations. These factors include differences in vehicle loads due to air conditioning, extra passengers or other cargo, trailer towing, and others.

An important aspect of the methodologies employed is that they are not only designed to compute total daily emissions for the region, but they are also designed to distribute the emissions geographically and by hour of the day. This feature is necessary to provide proper input to the air quality models being employed to assess the air quality impacts of alternative control strategies. Future changes or improvements to the methodologies used should include consideration of the detailed data requirements of the air quality models to which they are input.

THE OVERALL DESIGN

The calculation of motor vehicle emissions is logically divided into two separate parts. The first part deals with emissions which occur on major streets and highways from vehicle engines that are fully "warmed-up" (i.e., hot stabilized). The second part covers emissions which occur primarily

---

1 U.S. Environmental Protection Agency, "Compilation of Air Pollutant Emission Factors," Supplement 8, June 1977.

2 Letter from Daniel Lieberman, California Air Resources Board to Eugene Leong, ABAG, July 12, 1977, re: Supplement 8 Emission Factors.

at the beginning and end of each trip due to different engine operating characteristics. These emissions are referred to as cold start, hot start, and hot soak. The data required to compute each of these two aspects of motor vehicle emissions are quite different, as are their resulting geographic and hourly distributions.

The highway- or "link"-related hot stabilized emissions are computed using modified versions of two computer codes previously developed for the Federal Highway Administration.[3] The trip-end related emissions are computed through the use of programs developed at ABAG. The overall sequence of operation and input data requirements and sources for both codes are summarized in Figure 1. As shown, each set of programs outputs emissions on an hourly basis, geographically distributed by one kilometer UTM (Universal Transverse Mercator) grid squares. The two data sets are then merged for input to the air quality model (LIRAQ). For input, both codes require transportation data from the Metropolitan Transportation Commission (MTC) and emission factors from the California Air Resources Board. A summary of baseline transportation data inputs is shown in Table 1. More detailed technical descriptions of the calculation procedures are contained in Appendices A and B to this memorandum.

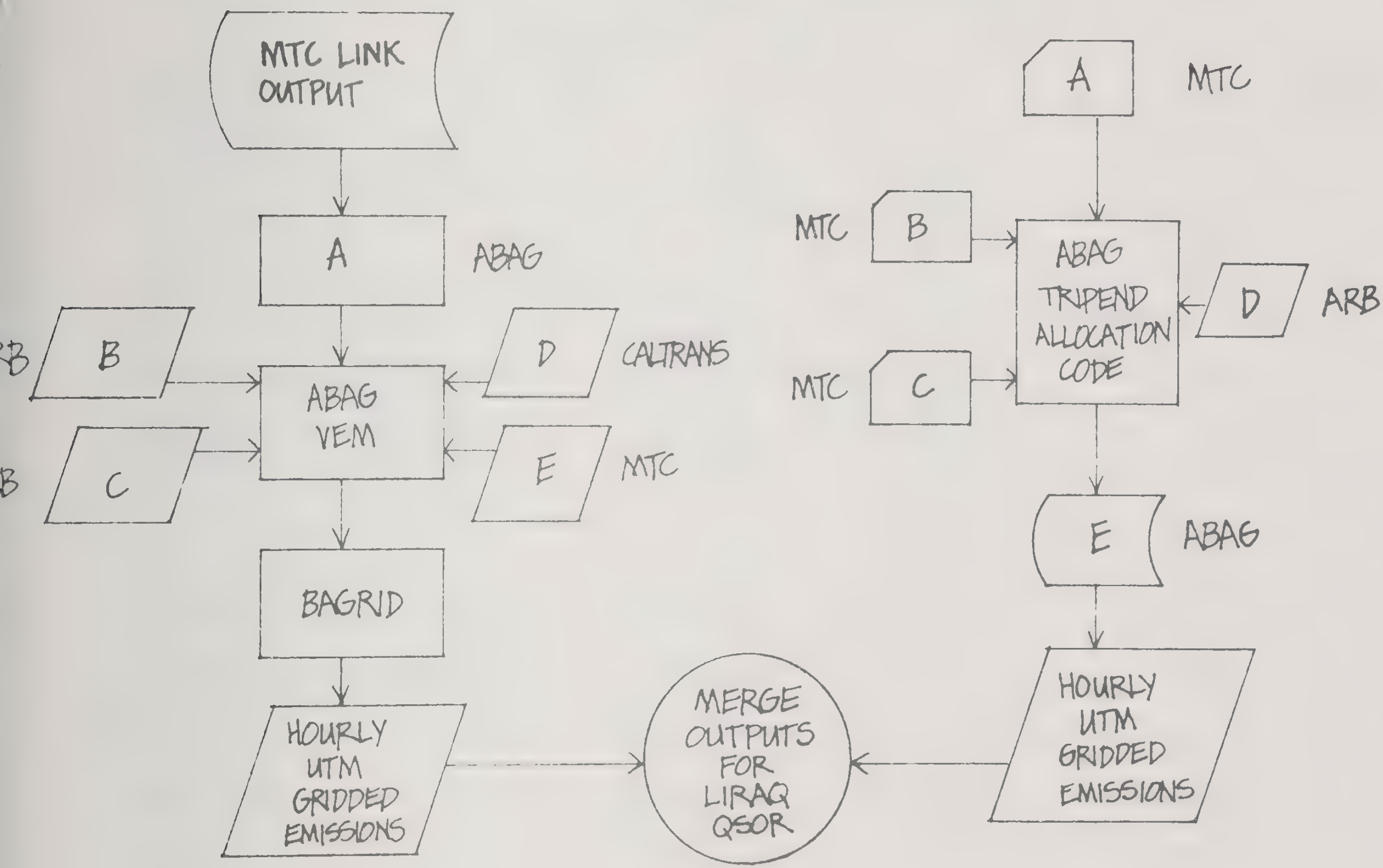
SUMMARY OF RESULTS

The total daily regional emissions from motor vehicles of three pollutants (hydrocarbons, carbon monoxide, and oxides of nitrogen) are summarized in Table 2. Motor vehicles also emit sulfur dioxide and particulate matter, but to a much less significant degree. From this table, it may be seen that trip end emissions are quite significant for hydrocarbon and carbon monoxide. This means that regardless of how short a given trip may be, the trip end emissions will still occur in substantial quantity. A second observation is that while automobiles contribute the majority of hydrocarbon and carbon monoxide emissions from motor vehicles, heavy duty gasoline and diesel trucks are significant contributors as well. A third observation is that emission levels for all three pollutants decline substantially between 1975 and 1985 due to the expected implementation of emission control programs now "on the books". However, from 1985 to 2000 the overall growth in vehicular activity begins to negate the gains made to 1985 for hydrocarbons and oxides of nitrogen, and goes well beyond that for carbon monoxide. In addition to the growth factor, a second significant factor leading to the long-term increase in emissions is the expected high rate of deterioration of emission control devices for conventional engines. Based on recent tests, EPA projects that future autos which meet stringent emission standards when new will not maintain the high degree of control for very long. If not improved or repaired, the poor endurance characteristics of current emission control technology will be a significant barrier to attainment and maintenance of ambient air quality standards in the San Francisco Bay Region. Similarly, the growth in vehicular activity from 1975 to the year 2000 will be substantial, and will significantly offset the gains expected from current control programs.

---

[3] Comsis Corporation, "User Documentation for ABAGVEM and BAGRID Auto Emission Analysis and Summary Programs," developed for Association of Bay Area Governments, April, 1977.

Figure-1 **ORGANIZATION OF THE MOTOR VEHICLE EMISSIONS CODE**



LINK EMISSIONS COMPONENT

Required input data:

A - State plane/UTM transform

B - Emission and deterioration factors for each model year for 1975, 1985, 2000

C - Motorcycle emission factors, SO_2 and particulate emission factors for all vehicles, weighted average for 1975, 1985, 2000

D - Updated speed correction equations for LDV, HDV, diesel

E - Percentage truck and motorcycle VMT by hour and functional road type

TRIP-END EMISSIONS COMPONENT

Required input data:

A - O-D trip tables for each travel model run (including intrazonal)

B - Hourly distribution of trip starts by trip purpose for four soak periods

C - Intrazonal VMT per zone

D - Cold start, hot soak emission factors for 1975, 1985, 2000 (weighted average over vehicle population)

E - 440 zone / 1 km grid conversion

TABLE 1. SUMMARY OF BASELINE TRANSPORTATION DATA INPUTS TO MOTOR VEHICLE EMISSIONS ESTIMATION

PARAMETER	YEAR			
	1965	1975	1985	2000[1]
VEHICLE TRIPS				
• Homebased work	1,706,983	2,144,693	2,542,951	3,038,406
• non-work	5,370,480	6,904,098	8,215,373	9,859,449
• LDV Total	7,077,463	9,048,791	10,758,324	12,897,855
VEHICLE MILES				
• Homebased work	14,055,453	20,199,644	23,645,050	30,309,087
• non-work	27,873,495	40,623,164	52,516,997	73,350,341
• LDV sub-total	41,928,948	60,822,808	76,162,047	103,659,428
• HDV @ 12.8%	5,366,905	7,785,319	9,748,742	13,268,407
• Total VMT	47,295,853	68,608,127	85,910,789	116,927,835

[1] Provisional Series III Base Case 1 Alternative

Source: Metropolitan Transportation Commission Memorandum from Hanna Kollo to Paul Maxwell, re AQMP Baseline Travel Projections, 5-23-77.

Table 2

SUMMARY OF BASELINE MOTOR VEHICLE EMISSION PROJECTIONS (tons/day)

(Revised 7/18/77 according to ARB Memo on EPA's Supplement 8 to Ap-42)

HYDROCARBONS	1975	1985	2000
Tripend	206.0	99.0	127.7
Link	266.3	113.9	140.0
Total	472.3	212.9	267.7

CARBON MONOXIDE	1975	1985	2000
Tripend	893	1,619	2,446
Link	2,976	1,849	2,564
Total	3,869	3,468	5,010

OXIDES OF NITROGEN	1975	1985	2000
Tripend	17.6	16.0	13.6
Link	381.8	239.1	271.9
Total	399.4	255.1	285.5
SULFUR DIOXIDE	18.7	24.7	33.6
PARTICULATES	43.0	35.1	42.1

APPROX. PERCENT OF EMISSIONS FROM EACH VEHICLE CLASS

	1975			1985			2000		
VEHICLE CLASS	HC	CO	NO_x	HC	CO	NO_x	HC	CO	NO_x
light duty autos	72%	61%	58%	55%	51%	35%	60%	50%	27%
light duty trucks and motorcycles	8%	9%	9%	8%	9%	6%	6%	8%	7%
heavy duty gas trucks	19%	28%	17%	33%	39%	28%	28%	40%	30%
heavy duty diesel	1%	2%	17%	5%	2%	30%	5%	2%	36%

APPENDIX A

COMPUTATION OF HOT STABILIZED, HIGHWAY LINK EMISSIONS

There are three basic calculations associated with the computation of motor vehicle emissions on the highway network:

- weighted average emission factors.
- speed correction factors.
- ambient temperature correction factors.

Emission factors have been derived from the California Air Resources Board's EMFAC3a code which includes a statewide average vehicle age distrubution and deterioration estimates. The resulting emission factors for the various vehicle types are summarized in Table 1. EMFAC3a computes separate factors for catalyst-equipped and non-catalyst-equipped vehicles.

ABAGVEM is a modified version of the Federal Highway Administration's SAPOLLUT code, and includes four vehicle types. These have been designated as light duty autos, heavy-duty gasoline trucks, heavy-duty diesels, and light-duty trucks combined with motorcycles. The emission factors in Table 1 have been grouped accordingly. Estimates of the percent of vehicles which are catalyst-equipped have also been obtained from EMFAC3a, and are as follows:

Percent of Catalyst Equipped Vehicles

Year	light-duty autos	light-duty trucks
1975	18%	1%
1985	98	96
2000	100	100

The distribution of total VMT among the various vehicle types was obtained from ARB, and is as follows:

Vehicle Type	LDA	LDT	HDG	HDD	Motorcycle
percent of LDV VMT (LDA+LDT)	86.2%	13.8%	8.6%	4.2%	0.9%

Speed correction factors were obtained from Cal Trans, "Motor Vehicle Emissions Factors for Estimates of Highway Impact on Air Quality" (August 1976), and are based on the equations in EPA's Supplement 5 to AP-42. Factors applicable to post-1970 vehicles were assumed to apply in all years of interest for the AQMP. For 1975, post-1970 vehicles account for over 60% of light-duty vehicle miles.

Estimates of speed on the highway network are computed within ABAGVEM according to the volume/capacity ratio on each link during each hour. Diurnal traffic distribution and the distribution of different vehicle types on different road types are also given default values in ABAGVEM. These values were estimated by FHWA during the development of the original SAPOLLUT.

The ambient temperature correction equations are identical to that employed in EMFAC3a and given in Supplement 5 to AP-42. The assumed diurnal temperature variation ranges from a minimum of 50° F. to a maximum of 75° F. This range is a compromise between the average summer min's and max's observed at different locations in the region, and the fact that the correction factor is insensitive to temperatures above 80° F. The actual input temperatures are as follows:

Hour	0-4	4-6	6-7	7-8	8-9	9-10	10-12	12-17	17-18	18-19	19-20
Temp.	55	50	55	60	65	70	75	75	70	67	64

Hour	20-21	22-24
Temp.	58	55

ABAGVEM computes emissions on all highway links and writes them onto an intermediate tape file. Hydrocarbons are not divided into the three levels for LIRAQ at this stage. ABAGVEM computes various forms of summary data including hourly emissions for the entire network and by road type, VMT for each vehicle type, and total daily emissions on the network.

A separate program, BAGRID, reads the tape file produced by ABAGVEM, converts the state plane coordinates of the network to UTM coordinates, allocates the emissions to appropriate grid squares, splits hydrocarbons into the three LIRAQ classes, and writes a tape file in the standard QSOR format for LIRAQ input. With BAGRID it is possible to change the boundaries of the grid to be used, and to change the allocation of hydrocarbons to the three LIRAQ classes.

The final step in the process involves the transfer of the output tape file from BAGRID to the LBL system. Since MTC's travel models reside at the CUC IBM facility, and LIRAQ resides on the LBL CDC facility, the tape produced at CUC must be converted to a format compatible with LBL. The tape must be physically transported from CUC to LBL, entered into the LBL tape library and converted onto an LBL library tape. This is done via an LBL utility program, CODE 9, which converts the CUC nine track EBCDIC tape to an LBL seven track BCD tape. Once this conversion is completed, the resulting tape is ready for imput to the LIRAQ QSOR file.

TABLE 2. HOT STABILIZED EMISSION FACTORS @ 20 mph (gms/mi)
*(Revised 7/21/77 to include Supplement 8 ARB ratios)

Year	Pollutant	LDA CAT	LDA non-CAT	LDA WTD avg.*	HD gas*	HD diesel*	LDT CAT	LDT non-CAT	LDT Wtd avg.*	Moto.	WTD avg.*
1975	CO	1.29	40.11	36.52	265.16	27.92	22.69	39.03	42.79	34.00	42.30
	NOx	1.95	3.70	3.39	10.86	21.96	5.10	4.67	3.74	0.19	3.52
	HC	0.23	4.36	3.99	25.43	3.86	1.28	4.63	4.13	10.00	4.51
	SO_2	0.13	0.13	0.13	0.36	2.80	0.18	0.18	0.18	0.028	0.17
	part.	0.25	0.54	0.49	1.21	1.30	0.25	0.54	0.54	0.16	0.52
1985	CO	1.07	48.64	6.20	228.11	20.30	3.82	53.58	6.79	25.0	7.98
	NOx	1.23	4.27	1.03	9.41	21.29	2.29	5.36	1.44	0.25	1.37
	HC	0.17	5.95	0.50	12.90	3.86	0.40	7.08	0.59	3.50	0.57
	SO_2	0.13	0.13	0.13	0.36	2.80	0.18	0.18	0.18	0.24	0.18
	part.	0.25	0.54	0.26	1.21	1.30	0.25	0.54	0.27	0.16	0.26
2000	CO	0.88	--	4.31	228.46	17.77	2.79	--	4.19	22.00	5.35
	NOx	1.10	--	0.66	8.69	21.29	2.13	--	1.28	0.31	1.22
	HC	0.17	--	0.51	9.08	3.37	0.36	--	0.47	1.60	0.54
	SO_2	0.13	--	0.13	0.36	2.80	0.18	--	0.18	0.24	0.18
	part.	0.25	--	0.25	1.21	1.30	0.25	--	0.25	0.16	0.24

Sources: California Air Resources Board, EMFAC3a output.
California Air Resources board, draft methodology for estimating motorcycle emissions.
USEPA, "Compilation of Air Pollutant Emission Factors", AP-42, Supplement 5. (for particulate emission factors).

APPENDIX B

COMPUTATION OF TRIP END EMISSIONS

The trip end emissions program computes hot start, cold start and hot soak emissions for all trip ends by zone and by hour of day. It also computes hot stabilized emissions for intrazonal trips. Total emissions are output in units of grams per second for each of the pollutant categories indicated below.

Emissions	Pollutant
Hot start	HC, NO_x, CO
Cold start	HC, NO_x, CO
Hot soak	HC
Hot Stabilized	HC, NO_x, CO, SO_2 particulates

Output data is organized in a format consistent with LIRAQ model requirements. Since output data is produced on a zonal basis, an additional transformation to a grid basis is required before the output data is input to LIRAQ. Trip data is provided from the MTC travel demand model. Emission factors, speed correction and ambient temperature correction factors are developed from the ARB mobile source emissions program EMFAC3A with appropriate corrections to include data from EPA's AP-42 Supplement 8.

A flow chart of the program is shown in Figure 1. This is followed by detailed descriptions of how hot soak emission factors, trip starts, trip stops, hot start and cold start emissions, hot soak emissions and hot stabilized emissions (for intrazonal trips) are computed. In all cases, emissions are calculated separately for the production and attraction trip ends and for each of five purposes (home-based work, home-based shop, home-based social-recreational, non-home based and external*) and then summed to yield total emissions.

This is necessary because hot/cold starts and hot soak emissions are functions of parking time before and after the trip is made respectively. These times will generally vary depending on the trip purpose and trip end type. In addition hourly trip distribution patterns at the production end differ from those at the attraction end for any given purpose.

All trips having one end at home are considered produced at the home end and attracted at the other end, irrespective of the direction. Non home-based trips are produced at the origin and attracted at the destination.

Trip stops and starts, the basis for computing all trip end emissions, are computed by disaggregating trip productions and attractions according to factors developed by MTC.

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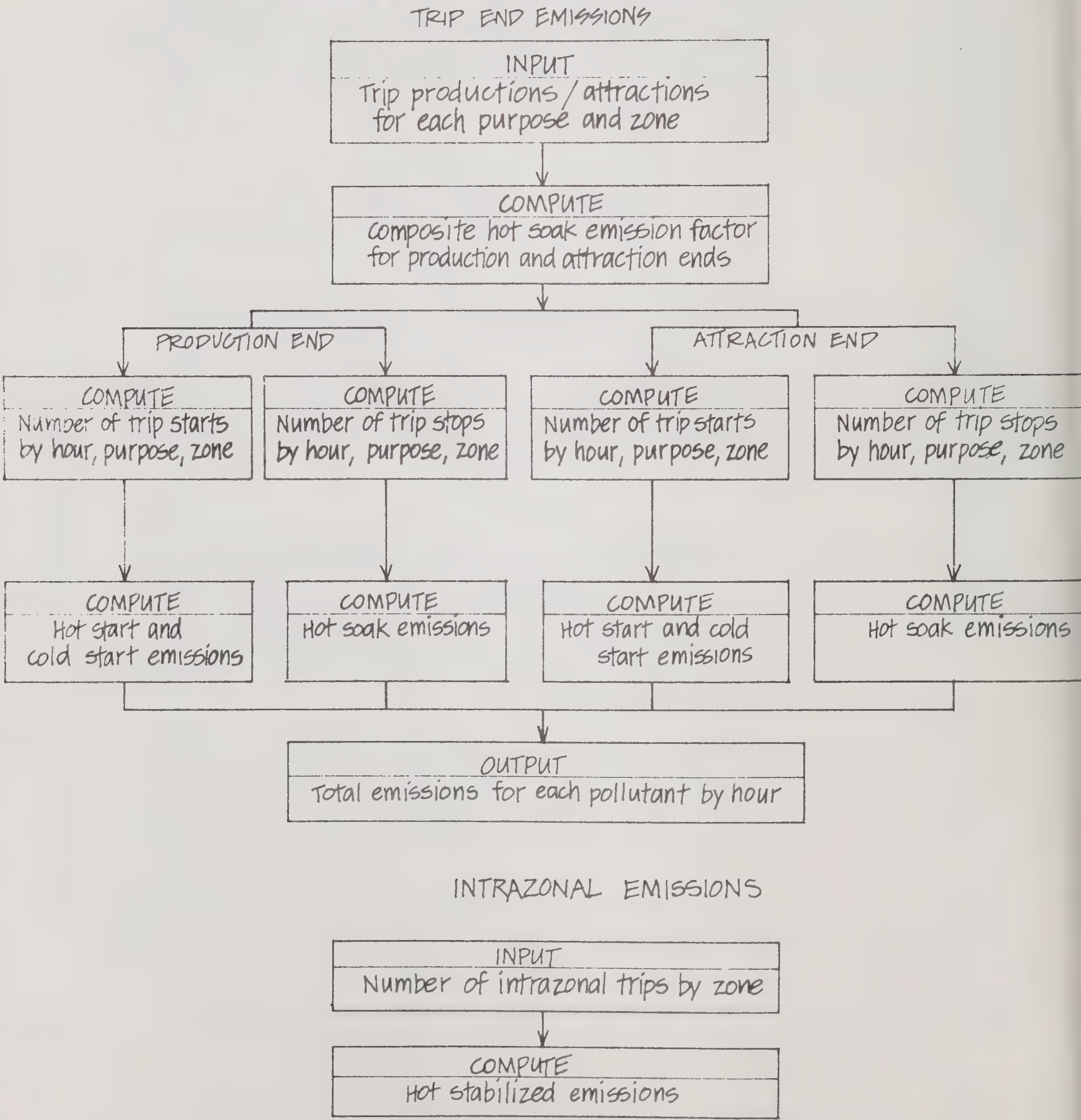
* External trips are assumed to have the same hourly distribution, hot soak and cold start profiles as non home-based trips. These two purposes are therefore summed early in the program and referred to as non home-based trips throughout the program description.

Figure 1 **FLOWCHART OF TRIP END EMISSIONS PROGRAM**



A. COMPUTATION OF HOT SOAK EMISSION FACTOR

For each purpose, P :

$$EMSOAKP(P) = \sum_{I=1}^{5} TSOAKP(I,P) \times \frac{ESOAK(I)}{100} \times HSOAK$$

$$EMSOAK(P) = \sum_{I=1}^{5} TSOAKA(I,P) \times \frac{ESOAK(I)}{100} \times HSOAK$$

where

EMSOAKP(P) = weighted hot soak emission factor for trip stops at the production end, for purpose P.

TSOAKP(I,P) = percent of total trip stops for purpose P at production end that have a hot soak period represented by I.

ESOAK (I) = % of 1 hour emissions in hot soak period. I (100% = 1 hour)

$$I = \begin{cases} 1 \text{ for } & 0\text{-}11 \text{ minutes} \\ 2 \text{ "} & 12\text{-}23 \text{ "} \\ 3 \text{ "} & 24\text{-}35 \text{ "} \\ 4 \text{ "} & 36\text{-}47 \text{ "} \\ 5 \text{ "} & 48\text{-}60 \text{ "} \end{cases}$$

EMSOAKA(P) = weighted hot soak emission factor for trip stops at the attraction end, for purpose P.

TSOAKA(I,P) = percent of total trip stops for purpose P at the attraction end with a hot soak period, I.

HSOAK = hot soak emission factor for one hot soak period.

The data for TSOAKP and TSOAKA were de eloped from the Sacramento Area Transportation Study (SATS) by Caltrans. As the MTC and SATS trip purpose definitions differ somewhat, the following equivalences were assumed:

MTC	SATS
home-based work	home-work
home-based shop	home-shop
home-based social recreation	home-other
non-home-based	other-other
external	other-other

Hot soak data for the SATS trip purpose, other-work was not included as no equivalence could be made.

Hot soak emissions are computed for catalyst vehicles only. The hot soak emission factor for light-duty vehicles is as follows:

HSOAK

Pollutant	YEAR 1975	1985	2000
HC	24.30	5.24	2.00

Values for TSOAKP, TSOAK and ESOAK are as follows:

PERCENT TRIPS AT PRODUCTION END (TSOAKP)

Hot Soak Period (minutes)	Purpose 1	2	3	4
0-11	06.7	04.1	07.8	0.0
12-23	08.1	03.2	04.9	0.0
24-35	04.6	01.5	04.8	0.0
36-47	03.1	00.9	01.6	0.0
48-60	77.4	90.3	90.9	0.0

SOURCE: SATS

PERCENT TRIPS AT ATTRACTION END (TSOAKA)

Hot Soak Period	Purpose 1	2	3	4
0-11	02.9	35.3	43.0	53.0
12-23	02.1	25.2	08.	15.0
24-35	01.4	09.	05.3	08.0
36-47	01.0	05.3	03.	03.0
48-60	92.6	25.2	40.7	21.0

SOURCE: SATS

Hot Soak Period	Percent of 1 hour Emissions (ESOAK)
0-11	11
12-23	42
24-35	70
36-47	84
48-60	94

SOURCE: AIR RESOURCES BOARD

The computed values for EMSOAKP and EMSOAKA are:

	Purpose	EMSOAKP (grams/trip)	EMSOAKA (grams/trip)
1985	H-B Work	4.33	4.72
	H-B Shop	4.64	2.56
	H-B Soc-Rec	4.38	2.76
	NHB	0.0	2.10

	Purpose	EMSOAKP (grams/trip)	EMSOAKA (grams/trip)
2000	H-B Work	1.65	1.80
	H-B Shop	1.77	.98
	H-B Soc-Rec	1.67	1.05
	NHB	0.0	.80

B. COMPUTATION OF TRIP STARTS

For each zone Z, purpose P, and hour H:

SSTARTP = TRIPP(Z,P) x STARTP(P) x PCTSTP(H,P)

SSTARTA = TRIPA(Z,P) x STARTA(P) x PCTSTA(H,P)

where =

SSTARTP = number of trip starts at production end, for zone Z, purpose P and hour A.

SSTARTA = number of trip starts at attraction end, for zone Z, purpose P and hour H.

TRIPP(Z,P) = total trip productions from zone A, for purpose P (includes intrazonal trips).

TRIPA(Z,P) = total trip attractions from zone Z, for purpose P (includes intrazonal trips).

STARTP(P) = percent of production trips, for purpose P, that are trip starts.

STARTA(P) = percent of attraction trips, for purpose P, that are trip starts.

PCTSTP(H,P) = percent of production trip starts made in hour H, for purpose P, $\sum_{H}$ PCTSTP(H,P) = 1.0

PCTSTA(H,P) = percent of attraction trip starts made in hour H, for purpose P, $\sum_{H}$ PCTSTA(H,P) = 1.0

Input values for TRIPP, TRIPA, TRIPI, STARTP, STARTA, PCTSTP, PCTSTA are from the MTC travel demand model. Values for STARTP and STARTA are given below:

PURPOSE	STARTP	STARTA
HB WORK	0.536	0.464
HB SHOP	0.487	0.513
HB SOC.REC.	0.472	0.528
NHB	1.000	0.000

SOURCE: MTC

HOUR	HOME-BASED PCTSTP	WORK PCTSTA	HOME-BASED PCTSTP	SHOP PCTSTA	HOME-BASED PCTSTP	SOC-REC PCTSTA	NON-HOME BASED PCTSTP(=PCTSTA)
1	.02	1.51	.11	.25	.11	3.15	.18
2	.02	.72	.06	.15	.09	1.57	.15
3	.08	.46	.01	.09	0.00	.79	.03
4	.71	.22	.13	.10	.33	.39	.22
5	3.06	.10	.28	.07	.32	.03	.26
6	14.19	.20	1.47	.48	1.25	.09	.46
7	37.03	.69	5.19	1.70	2.27	.40	1.31
8	18.75	.88	7.30	3.75	3.01	.22	2.87
9	4.86	.61	7.20	2.82	4.83	.83	4.66
10	1.98	.62	8.98	3.93	5.27	1.03	8.33
11	1.70	1.62	7.26	6.41	6.37	2.44	10.32
12	3.38	4.68	5.39	6.95	5.23	3.82	12.10
13	2.53	1.77	7.00	5.38	5.53	3.53	10.32
14	2.25	2.13	7.36	6.50	4.7	4.25	9.42
15	2.90	5.27	6.91	8.95	4.38	5.59	9.17
16	1.28	17.63	7.21	10.27	4.16	7.18	9.46
17	1.29	30.44	6.76	12.76	6.36	7.36	6.79
18	.96	15.22	6.35	8.60	14.54	6.77	3.75
19	.77	3.82	8.70	5.49	17.32	6.55	3.06
20	.46	2.02	3.5	5.09	8.62	8.14	3.03
21	.36	2.97	1.47	5.15	3.40	11.00	1.87
22	.67	1.89	.71	2.78	1.10	10.10	1.05
23	.68	1.92	.47	1.59	.65	9.11	.80
24	.05	2.61	.16	.75	.16	5.66	.41
Total	100.00	100.00	100.00	100.00	100.00	100.00	100.00

SOURCE: MTC

C. COMPUTATION OF TRIP STOPS

For each zone Z, purpose P, hour H :

SSTOPP = TRIPP(Z,P) x STOPP(P) x PCTSTA(H,P)

SSTOPA = TRIPA(Z,P) x STOPA(P) x PCTSTP(H,P)

where

SSTOPP	=	number of trip stops at producttion end, for zone Z, purpose P and hour H.
SSTOPA	=	number of trip stops at attraction end, for zone Z, purpose P and hour H.
TRIPP(Z,P)	=	total trip productions (includes intrazonal trips).
TRIPA(Z,P)	=	total trip attractions (includes intrazonal trips).
TRIP I(Z,P)	=	total intrazonal trips.
STOPP(P)	=	percent of trip productions that are trip stops (= STARTA(P))
STOPA(P)	=	percent of trip attractions that are trip stops (= STARTP(P))
PCTSTA(H,P)	=	percent of production trip stops made in hour H (= percent attraction trip starts in hour H)
PCTSTP(H,P)	=	percent of attraction trip stops made in hour H (= percent production trip starts in hour H)

Values for STOPP and STOPA are as follows:

PURPOSE	STOPP	STOPA
H-B Work	.464	.536
H-B Shop	.513	.487
H-B Soc. Rec.	.528	.472
NHB	0.0	1.0

Source: MTC

D. COMPUTATION OF HOT START EMISSIONS

For zone Z, purpose P, hour H, pollutant N :

HOTSTRT = SSTARTP x CAT x TPKP x EMHOT(N) x TEMCOR3 (DEGREE, N)
+
SSTARTA x CAT x TPKA x EMHOT(N) x TEMCOR3 (DEGREE,N)

HOTSTRT = hot start emissions for zone Z, purpose P, hour H, pollutant N (in grams)

SSTARTP = production starts in zone Z, purpose P, hour H

SSTARTA = attraction starts in zone Z, purpose P, hour H

CAT = percent catalyst vehicles in vehicle fleet

TPKP = percent of production starts where vehicles are parked less than one hour before beginning trips

TPKA = percent of attraction starts where vehicles are parked less than one hour before beginning trips

EMHOT(N) = hot start emission factor for pollutant N (in grams/trip)

TEMCOR3 (DEGREE,N) = temperature correction factor for pollutant N and catalyst vehicles

DEGREE = temperature at hour H

Hot start emission factors, weighted for light-duty vehicles (includes trucks), are as follows:

	Hot Start Emission Factor (grams/trip)		
	1975	1985	2000
Pollutant	catalyst	catalyst	catalyst
CO	9.35	23.24	30.98
THC	1.00	1.33	2.13
NOx	1.2	0.66	0.45

Source: Derived from data provided by ARB-EMFAC 3A (includes wtd avg of LDA and LDT, Hot stabilized emissions for the first 3.59 miles have also been subtracted as suggested by B. Loscutoff, ARB)

E. COMPUTATION OF COLD START EMISSIONS

For each zone Z, purpose P, hour H, pollutant N,

COLDSTR = SSTARTP x CAT x TPCSTP (I,P) x EMCOLDC(N) x TEMCOR1 (DEGREE, N) +

SSTARTP x CATN x TPKSTP(4,P) x EMCOLDN(N) x TEMCOR2 (DEGREE, N) +

SSTARTA x CAT x TPKSTA(I,P) x EMCOLDC(N) x TEMCOR1 (DEGREE,N) +

SSTARTA x CATN x TPKSTA(4,P) x EMCOLDN(N) x TEMCOR2 (DEGREE,N)

where

COLDSTR = cold start emissions for zone Z, purpose P, hour H, pollutant N (grams)

SSTARTP = production starts for zone Z, purpose P, hour H

SSTARTA = attraction starts for zone Z, purpose P, hour H

CATN = % non-catalyst vehicles in vehicle fleet (CAT+CATN=1.0)

TPKSTP(T,P) = percent production starts where vehicles are parked greater than T hours before beginning trips (T=1, for catalyst vehicles and T=4, for non-catalyst)

TPKSTA(T,P) = percent attraction starts where vehicles are parked greater than T hours before beginning trips (=1 for catalyst, =4 for non-catalyst)

EMCOLDC(N) = cold start emission factor for pollutant N, catalyst vehicles

EMCOLDN(N) = cold start emission factor for pollutant N, non-catalyst vehicles

TEMCOR 1 (DEGREE,N)= temperature correction for pollutant N, catalyst vehicles

TEMCOR 2 (DEGREE,N)= temperature correction for pollutant N, non-catalyst vehicles

Cold start emission factors, weighted to incl'de all light-duty vehicles, are as follows:

	Cold Start Emission Factor (grams/trip)					
	1975		1985		2000	
	catalyst	non-cat	catalyst	non-cat	catalyst	non-cat
CO	53.24	200.8	133.	258.4	175.	0.0
THC	4.48	7.9	5.97	12.0	9.55	0.0
NO_x	2.03	0.0	1.13	0.0	0.77	0.0

Temperature correction factors are described in a later section. The percent cold start trips (from SATS) are shown below:

% Cold Start Trips (Catalyst)

Purpose	Production End (TPKSTP)	Attraction End (TPKSTA)
H-B Work	89.4	90.9
H-B Shop	78.4	21.6
H-B Soc. Rec	73.3	40.5
NHB	21.1	-

% Cold Start Trips (Non-Catalyst)

Purpose	Production End (TPKSTP)	Attraction End (TPKSTA)
H-B Work	80.7	74.7
H-B Shop	51.8	4.3
H-B Soc. Rec.	51.5	10.9
NHB	6.1	-

Source: SATS

F. COMPUTATION OF HOT SOAK EMISSIONS

For each zone Z, purpose P, hour H

SOAK = (SSTOPP x EMSOAKP(P)) + (SSTOPA x EMSOAKA(P))

where

SOAK = hot soak emissions for zone Z, purpose P, hour H (hydrocarbons only)

SSTOPP = number of production stops for zone Z, purpose P, hour H

SSTOPA = number of attraction stops for zone Z, purpose P, hour H

EMSOAKP(P) = composite hot soak emission factor over one hour for trips at production end for purpose P

EMSOAKA(P) = composite hot soak emission factor over one hour for trips at attraction end for purpose P

G. COMPUTATION OF INTRAZONAL HOT STABILIZED EMISSIONS

For each zone Z, purpose P, hour H, pollutant N :

RUNEMSS = TRIPI(Z,P) x VMTINT(Z) x PCTSTP(H,P) x EMRUN(N)
x SPEEDCR(Z,N)

where

TRIPI(Z,P)	=	total intrazonal trips
VMTINT(Z)	=	one half the distance from the zone Z's centroid to the nearest centroid (miles)
PCTSTP(H,P)	=	percent of production starts made in hour H for purpose P
EMRUN(N)	=	composite hot stabilized emission for catalyst and non-catalyst vehicles pollutant N (grams/mile)
SPEEDCR(Z,N)	=	speed correction factor for zone Z, pollutant N (based on off peak speeds)

The variable values, TRIPI, VMTINT and PCTSTP are developed from the MTC travel demand model.

The hot stabilized emission factors are developed for a speed of 20 MPH, to which a zonal speed correction factor, SPEEDCR, is applied. The emission factors are as follows:

	Hot Stabilized Emission Factor (grams/mile)		
Pollutant	1975	1985	2000
CO	37.3	7.20	5.06
THC	4.14	0.58	0.56
NO_x	3.57	1.17	0.74
SO_2	.14	.14	0.13
Particulates	.33	.25	0.25

The speed correction factors are developed from EMFAC3 for light duty vehicles, low elevation, post 1970 model years. Nine speed ranges are considered: from 0 to 45 miles per hour in increments of 5 MPH. Each zone has two correspondent speed values - peak and off-peak. This program utilizes the off-peak speed to obtain the appropriate zonal speed correction factor as shown below:

The temperature correction factor, TEMCOR3, and DEGREE, are described in section H.

The catalyst/non-catalyst split (CAT) is shown below:

	1975	1985	2000
CAT(%)	15.4	97.8	100.0

The percent hot start trips are as follows:

Purpose	% Hot Start Trips Production (TPICP)	Attraction (TPKA)
H-B Work	10.6	9.1
H-B Shop	21.6	78.4
H-B Soc. Rec.	26.7	59.5
NHB	78.9	-

Source: SATS

Speed Correction Factor (SPEEDCR)

Speed(MPH)	HC	NO_x	CO
0- 5	2.8	1.1	4.2
5-10	2.1	1.1	2.9
10-15	1.4	1.0	1.7
15-20	1.1	.9	1.1
20-25	.9	1.0	.9
25-30	.8	1.1	.7
30-35	.7	1.1	.6
35-40	.6	1.1	.5
40-45	.6	1.2	.4

H. AMBIENT TEMPERATURE CORRECTION FACTOR

The temperature correction factors are developed from Supplement 5 to AP-42. Given the hour of the day (1-24), the following table look-up is performed to obtain the appropriate ambient temperature (for all three test years):

Hour	12A-4A	4-6	6-7	7-8	8-9	9-10	10A-12P	12-5P	5-6	6-7
Temperature (F^{o})	55	50	55	60	65	70	75	75	70	67

Hour	7-8	8-9	9-10	10P-12
Temperature (F^{o})	64	61	58	55

Twelve correction factors for hot/cold start emissions, three pollutant categories and catalyst/non-catalyst vehicles are computed as follows:

$$\text{TEMCOR}=Z\left[\left(\frac{w + (100-w)\ f\ (t)}{20 + 80\ f(t)}\right)\right]\text{non-catalyst}$$

$$= Z\left[\left(\frac{w + xf(t) + (100-w-x)\ g(t)}{20 + 27\ f(t) + 53g(t)}\right)\right]\text{catalyst}$$

where
t = ambient temperature
w = 100 for cold starts
0 for hot starts
x = 100 for hot starts
0 for cold starts

Z, f(t), g(t) = as given in AP-42

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BENEFITS OF PHOTOCHEMICAL OXIDANT CONTROL

This paper summarizes the benefits of the Air Quality Maintenance Plan. The plan emphasizes the control of emissions that form photochemical oxidants, the most serious air quality problem in the Bay region. Reducing the concentration of photochemical oxidants has three types of benefits:

- Improvements in public health
- Reduction in damage to vegetation
- Reduction in damage to other materials

The effects of air pollution have been the subject of numerous studies over the past several decades.

While it has been difficult to make definitive statements from any single study on the incremental dose effects of air pollutants, the cumulative evidence undeniably demonstrates that adverse effects result from exposure to high levels. These are summarized in the following sections. A reference list of the technical documents which support the findings is also provided.

The adverse effects described herein would be reduced significantly or eliminated as the plan is carried out. These improvements therefore constitute the benefits of air pollution control.

Effects on Human Health

Photochemical oxidants have been found to cause eye irritation, nasal irritation, irritation of mucous membranes, respiratory distress and difficult breathing, increased fluid in the lungs, coughing, rapid pulse rate, lowered blood pressure, asthma attacks, and overall decrease in the quality of human performance.

Some of these effects have been observed at relatively low oxidant levels. In other cases, short-term exposure to relatively high oxidant or ozone levels has produced few if any negative effects. There are two reasons for such variable results. One is that pollution combines with many other factors to affect health. For example, under certain conditions, even low oxidant levels can be harmful. The other reason is that each individual responds differently to oxidant exposure. Thus, the Federal standards for oxidant levels have been set to protect sensitive population groups--and that includes most people at one time or another--children, the elderly, and the chronically or temporarily ill.

A large number of statistical studies, clinical analyses of specific case histories, and controlled experiments have been conducted to determine the effects of photochemical oxidant or ozone exposure. Effects from short-term exposure to high pollutant levels are more easily observed than are effects from long-term exposure to more moderate levels. Following is a brief summary of effects observed in some of these studies. As a point of reference, high levels of oxidant in the region frequently reach 2-3 times (.16 - .24 ppm) the 0.08 ppm standard, depending on meteorlogical conditions.

- In several American studies,[1,2] eye irritation has been observed at daily maximum hourly concentrations ranging from about 0.1 ppm to about 0.15 ppm. Recent Japanese studies[3,4] raise the possibility that even lower oxidant concentrations may contribute to eye irritation under certain conditions. Such values, as previously shown, are quite typical of levels reached in the Bay Area. The consistency of the association between short-term oxidant exposures and eye irritation arouses concern about the long-term effects of such exposures.

- Several studies (see references 5,6,7,8 and 9) have noted a gradual decrease in human athletic performance under short-term exposures to photochemical oxidant. Investigators observed that high-school cross country runners did not perform as well when hourly concentrations increased from about .03 to .30 ppm. Best performances were almost always on days of low oxidant concentrations. Other similar studies suggest that on high-oxidant days, the irritant effects of pollutants may have restricted the runners' mechanical lung function sufficiently to prevent them from taking in enough oxygen to support their potential performance levels.

- Respiratory distress in healthy people, especially children, has been frequently noted (see references 2,4,10,11 and 12). Symptoms observed in school children, including sore throat, headache, cough and difficult breathing, were higher on days when maximum hourly oxidant levels equalled or exceeded .15 ppm than on days when concentrations were below .10 ppm.

- Short-term oxidant exposure has also been associated with aggravation of existing disease (see references 13,14,15,16,17 and 18). Thus, individuals with existing respiratory ailments are more likely to be affected by oxidant pollution.

- Investigators have observed[19] a significantly higher rate of asthma attacks on days when oxidant concentrations exceeded .25 ppm.

- A 1973 study[20] measured significant impairment in lung function in 10 normal male subjects aged 23-53 years (including two smokers) exposed to pure ozone at 0.75 ppm for 2 hours. Two of the three subjects who exercised intermittently showed accentuated effects. In other similar experiments, most subjects complained of cough, chest tightness, and soreness. A few also had pharyngitis, difficult breathing and wheezing.

- Some limited studies[2,8] have shown evidence of human health effects from ozone at concentrations of 0.25 ppm and preliminary findings of a 1976 study suggests lowered lung function at 0.1 ppm exposure for 2 hours.

Additional studies on occupational exposure to ozone are summarized in Table 1. It is evident from the table that a wide range of responses has been observed. Investigators recognize that short-term exposure to high pollutant levels can indicate the potential for serious problems from long-term exposure to moderate or low levels. While specific effects may not be the same in both cases, controlled experiments and clinical appraisals show that exposure to oxidant and ozone concentrations could have serious health effects. Results from a number of controlled human exposure to ozone studies are given in Table 2.

Effects on Vegetation

Oxidant injury to vegation was first identified in 1944 in the Los Angeles basin. The understanding of oxidant effects and of the widespread nature of their occurence has increased steadily since then. Observed effects on plant life include visible foliar injury and discoloration, increased leaf drop, reduced plant vigor, reduced plant growth, and death.

Biological effects occur not only in individual plants but also in plant communities and entire ecosystems. The implications of oxidant exposure to agricultural crops are dramatic.

- Field experiments compared yields of crops grown in clean air and air with typical ozone concentrations. These experiments showed up to 50% decreases in citrus yield; 10%-15% suppression in grape yield in the first year and 50%-60% reduction over the following two years; and a 5%-29% decrease in yield of cotton lint and seed in California (see references 21,22,23,24 and 25).

- Losses of 50% in some sensitive potato, tobacco and soybean cultivars have been reported in the eastern United States (see references 26,27, 28 and 29).

- Reductions in yield, with little accompanying injury, have been noted for several crops. Severe injury was required to cause reduction in tomato yield. Chronic exposures to ozone at .05 to .15 ppm for 4 to 6 hours per day produced reductions in yield in soybean and corn grown under field conditions. The threshold concentration for ozone appears to be between .05 and .10 ppm for sensitive plant cultivars.

- Adverse effects of short-term exposure to ozone have been noted at the following levels and durations:

Trees and shrubs:	.2 to .51 ppm for 1 hour duration
	.2 to .25 ppm for 2 hours duration
	.06 to .17 ppm for 4 hours duration
Agricultural crops:	.2 to .41 ppm for .5 hour duration
	.1 to .25 ppm for 1 hour duration
	.04 to .09 ppm for 4 hours duration

Table 1. SUMMARY OF SELECTED DATA ON OCCUPATIONAL EXPOSURE OF HUMANS TO OZONE

Ozone, ppm	Subjective compliants	Clinical findings attributed to ozone	Measurements of pulmonary function	Other comments
0.25	None	None	None	-
0.3 to 0.8	Chest constriction and throat irritation in 2 to 4 subjects	None	None	-
0.2	-	None	None	-
0.8 to 1.7	Dry mouth and throat, irritation of nose and eyes, disagreeable smell in 11 of 14 subjects	None	None	Concentration of trichloroethylene up to 238 ppm found
0.2 to 0.3	Irritating odor, soreness of eyes, and dryness of mouth, throat, and trachea in 1 of 7 subjects	None	VC decrease in 3 of 7 subjects. FRC decreased in 2 of 7 subjects. DL_{CO} decreased in 1 of 7 subjects.	All decreases in pulmonary function measurements were small. All subjects were smokers.
0.4	Discomfort and irritation in about 30 minutes	None	None	-
0.47	Distinct irritation of mucous membranes	None	None	-

Source: U.S. Environmental Protection Agency, "Air Quality Criteria for Photochemical Oxidants and Oxidant Precursors," Volumes I-II, DRAFT NO. 1, September 1977.

Table 2. SUMMARY OF SELECTED DATA ON HUMAN EXPERIMENTAL EXPOSURE TO OZONE

Ozone, ppm	Length of exposure	No. and sex of subjects	Subjective complaints	Measurements of pulmonary function	Other comments
0.2	3 hr/day 6 days/wk, for 12 wk	6 male	None	VC: no change $FEV_{1.0}$: no change	0.66 upper respiratory infections/ person in 12 weeks. Control group had 0.95 in the same period
0.5	3 hr/day 6 days/wk, for 12 wk	6 male	No irritating symptoms but could detect ozone by smell	VC: slight decrease but not significant decrease toward end of 12 weeks. Returned to normal within 6 weeks after exposure.	0.80 upper respiratory infections/ person in 12 weeks
0.1	1 hour	4 male		Airway resistance: mean increase 3.3% at 0 hours after exposure (1/4 subjects showed an increase of 45%)	One subject had history of asthma, and experienced hemoptysis 2 days after 1 ppm
0.4	1 hour	4 male	Odor	Airway resistance: mean increase 3.5% at 0 hours after exposure (1/4 subjects showed an increase 12.5% 1 hour after exposure	

Table 2. (Continued) SUMMARY OF SELECTED DATA ON HUMAN EXPERIMENTAL EXPOSURE TO OZONE

Ozone, ppm	Length of exposure	No. and sex of subjects	Subjective complaints	Measurements of pulmonary function	Other comments
0.6	1 hour	4 male	Odor	Airway resistance: mean increase 5.8% at 0 hour after exposure (1/4 subjects showed an increase of 75%), mean increase 5% 1 hour after exposure	

<u>Source</u>: U.S. Environmental Protection Agency, "Air Quality Criteria for Photochemical Oxidants and Oxidant Precursors," Volumes I-II, DRAFT NO. 1, September 1977.

- According to a 1975 report by the State Department of Food and Agriculture, certain crops are no longer grown in the Bay Area because of air pollution.[30] Among these crops are snap dragons and chrysanthemums.

- In the Bay Area ornamental growers have relocated their greenhouses from San Francisco to Half Moon Bay. Similarly, rose growers have moved to Salinas to avoid air pollution damage.[30]

- According to recent surveys by the State Department of Food and Agriculture, crops seriously damaged in the Bay Area are grapes, carnations, and orchids.[30]

- Estimated loss to cut flower growers in the Bay Area in 1970 was approximately $1 million.[30]

- Estimates of total annual statewide agricultural damage from air pollution have ranged widely from tens of millions of dollars to almost a half billion dollars.[30] While much of this damage occurs in the Los Angeles and San Joaquin Valley areas, a significant portion also occurs in the Bay Area.

- The available data would suggest annual agricultural damage in the Bay Area from oxidant air pollution may range from several million dollars upwards to tens of millions of dollars.

It is clear that trees, shrubs and agricultural crops are affected by the levels of oxidant air pollution which occur in the Bay Area. It can therefore be concluded that a reduction in oxidant levels can have a very significant beneficial effect on plant life.

Effects on Materials

Just as with humans or plant life, air pollution can have negative effects on man-made materials. Ozone can accelerate the aging of rubber products (see references 31,32 and 33) and can cause dye fading in clothes (see references 34,35 and 36), carpeting and other textiles.[37] It can reduce the life of industrial maintenance points and vinyl and acrylic coil coatings. Textile fibers can also be damaged by ozone, resulting in accelerated aging.

The cost of such materials damage takes two forms.[38] There is the cost to the producer who must take preventive measures to protect the product from ozone damage. There is also the costs to cor umers. The consumer pays for such damage through earlier replacement of materials. For example, one study estimated the national cost of ozone fading--e.g. nylon carpets, permanent-press garments, acetate and triacetate textiles--to be approximately $80 million annually.

Figure 1 presents a summary of the estimated total annual per capita cost of ozone damage and preventive measures as a function of annual ozone concentrations. In 1975, the annual average ozone concentration in the Bay Area was between .015 and .025 ppm. Thus, Bay Area residents paid between $10 and $33 million as a result of ozone damage to materials that year. By the year 2000, all other factors being equal, that cost will have risen to between $12 and $39 million per year in 1975 dollars.

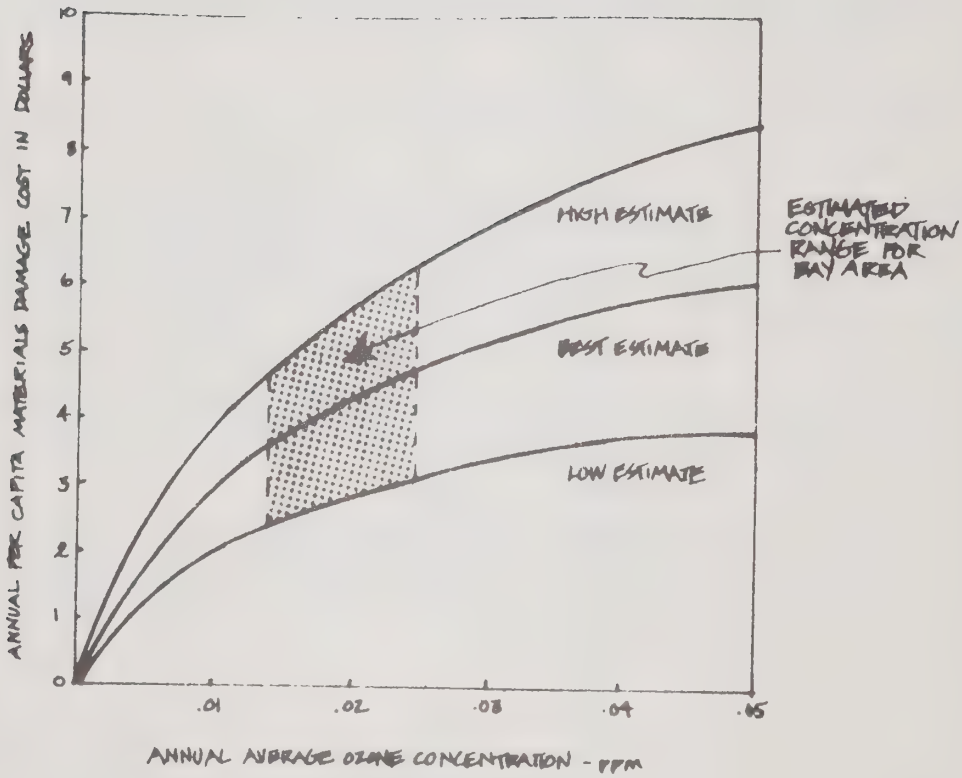

FIGURE 1.

EFFECT OF ANNUAL AVERAGE OZONE CONCENTRATION ON ADDED COSTS DUE TO DAMAGE TO MATERIALS AND PREVENTIVE MEASURES

Conclusion

The benefits to be realized from a significant reduction in oxidant levels may not always be quantifiable, but they are clear nevertheless. Air pollution has been found to have significant and negative effects on human health, plant life and materials. Maintenance of air quality standards thus plays a critical role in reducing the damages now experienced.

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AQMP/Technical Memorandum 14 September 1977
I. Kan

EFFECTIVENESS AND COSTS OF ALTERNATIVE AIR POLLUTION CONTROL PROGRAMS

The need for a comprehensive control strategy for dealing with the Bay Area Region air quality problem has been stressed in previous reports. Specific control measures for inclusion into such a strategy have now been identified by the Joint Technical Staff along with estimates of their effectiveness and cost. The purpose of this memorandum is to present this information in a manner that will allow the reader to evaluate, review and comment on the proposed measures.

Section I contains a description of how each of the candidate control measures would be implemented. Section II gives the estimates of control measure effectiveness for the target years, 1985 and 2000. Section III gives estimates of the direct costs of implementation. While key assumptions and data sources are provided, space limitations preclude a detailed description of the estimation methodology. Readers should contact the indicated person or agency responsible for the analysis if additional information is required.

I. CONTROL MEASURE SPECIFICATION

Candidate control measures for the AQMP have been presented in Technical Memorandum 5, Brief No. 2 and Brief No. 3 in summary form. In order to evaluate control measure effectiveness and cost, assumptions have been made on their specific manner of implementation, the degree of the control proposed and the affected source categories. These control measures are being developed primarily to achieve the maximum emissions reduction possible within the bounds of political and economic reality. Recognizing that political and economic reality can be different things to different people, the control measures have been specified so as to establish the upper bound on what would be required to attain and maintain air quality standards. The institutional, legal and financial requirements of control a well as the overall social, economic and other environmental impacts are subjects of separate reports.

Stationary Source Control Measures[1]

high solid and water-base coatings - This control reflects the Air Resources Board's model organic solvent rule (for architectural coatings) dated June 29, 1977 and assumes further controls on industrial and commercial coatings. It would affect approximately 500 industrial sources in the Bay Area.

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1 Developed by the Bay Area Air Pollution Control District (BAAPCD)

closed-system organic storage - This measure reflects new regulations requiring dual and parallel vapor recovery at 100% operation, on new and modified sources. It would affect approximately 1000 sources.

limit sulfur content to 300 ppm or equivalent mass - This measure assumes that significant reductions could be achieved with existing technology such as Bevon and Scott units, dual absorption. Improved, alternative methods are likely to be developed in the future.

limit sulfur content of fuel to 25% or the equivalent stack gas concentration - This measure assumes the establishment of fuel oil desulfurization facilities at six refineries by 1985. Emission reductions would be paid out at the refineries, eight power plants and industries with large combustion processes.

best available control technology (BACT) - BACT for thirty-two source categories in the District's inventory are listed in Attachment A. There is no consensus among "experts" for a uniform definition of BACT. The BACT's designated for the AQMP reflect technology that is known but not necessarily proven in California industrial operations.

new source review and limited trade-off - This measure is being studied separately and the results will be published at a future time. It assumes:

- o limited growth of heavy industry in the Bay Area (less than 1/2% per year)
- o a 1½% per year growth in particulate and organic emissions based on 1975-76 emissions
- o conversion of natural gas use age to fuel oil (.5% sulfur) and no coal
- o a 1% per year growth in energy usage (normal rate is 5%)
- o some modification of existing sulfur recovery units

Mobile Source Emission Control Measures[2]

more stringent exhaust emissions for light and meduim duty vehicles - This measure would require emissions characteristics for all new vehicles manufactured after 1990 to be reduced by 50% from the levels promulgated by the 1970 Clean Air Act. Although future technological improvements in the conventional internal combustion engine may satisfy this measure, it was assumed in the analysis of cost that alternative engine configurations (e.g. Brayton and Sterling--see Tech. Memorandum 8) would be developed to meet this new standard.

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[2] Developed by Air Resources Board (ARB)

more stringent exhaust emission standards for heavy duty vehicles - This measure would require that all new heavy duty vehicles manufactured in 1990 and after, satisfy the standards listed below.

	1970 Standards (gms/mi)			Current (gms/mi)			Control (gms/mi)		
Vehicle	HC	CO	NOx	HC	CO	NOx	HC	CO	NOx
light duty	.41	3.4	.4	1.5	15.	2.	.2	1.7	.2
medium duty	-	-	-	-	-	-	.25	4.5	.75
heavy duty*	-	-	-	-	-	-	2.25	12.5	2.25

*gms/BHP-hour

inspection/maintenance program for all vehicles - Administered by the Bureau of Automotive Repair and operated by a private franchise, this program would be self-supporting through the collection of inspection fees. It would be implemented in 1982 for light duty vehicles and 1985 for medium and heavy duty vehicles. A detailed description of this program will be given in a forthcoming issue paper.

exhaust retrofit program for heavy duty gasoline trucks - This measure would require that all 1971-1982 heavy duty gasoline vehicles be retrofitted with a catalytic converter by 1985. This measure would be implemented in two phases: a) 1971-76 model years would be required to be retrofitted by 1980; b) 1977-1982 vehicles would be required to be retrofitted by 1985. Vehicles manufactured in 1983 and after would be equipped with catalytic converters to meet the promulgated standards. It is also assumed that past 1971 vehicles operate on unleaded gasoline and thus can be fitted with converters.

Transportation Control Measures[3]

increase tolls - This measure assumes a toll of $1.25 on all trans-Bay bridges during the peak hours (6-9 a.m.) and $1.00 during off-peak hours. This measure would be implemented when sufficient transit capacity existed to absorb extra riders (presumably, former vehicle drivers who switch to transit as a result of the toll increase).

regional parking strategy - A prototypical regional parking strategy, developed for the purposes of evaluation, would be to:

- o impose a 35% parking tax on vehicles entering lots between 6 and 10 a.m. This tax would be applied to all paid parking in the region
- o eliminate free employee parking by requiring that commercial facilities with 500 or more parking spaces levy a 50¢ minimum charge - Commercial operators would keep a portion of this charge to cover the cost of collection

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3 Developed by the Metropolitan Transportation Commission (MTC)

- encourage employers to give preferential parking to carpools for parking lots of 500 or more spaces - The cost analysis of this measure is based upon an annual subsidy of $216 per vehicle for 472 preferential spaces in the San Francisco CBD. This subsidy would be granted by the California Department of Transportation.

The regional parking strategy would not be implemented until 1980.

additional transit service - This measure assumes transit improvements/expansion that would ultimately yield a 20% increase in transit service by 1985, i.e. an increase by the frequency of transit service, reduced wait time, reduced transfer time. The improvements program would be subsidized by the additional revenues from the toll increase and parking tax.

bus and carpool lanes with ramp metering - This measure assumes that ramp metering would be implemented at three locations:

- Route 580 from Route 24 to the Bay Bridge

- Route 580 from Gilman Street to the Bay Bridge

- Route 101 from the Bay Bridge to South San Francisco

auto-control zone in the San Francisco CBD - This measure differs somewhat from an auto-free zone in that it would not impose a total ban on private vehicles. Instead, this measure calls for a series of traffic control measures that would alleviate congestion and limit non-commercial vehicle traffic.

ride-sharing program - This measure would provide assistance and information to employees and employers who are interested in establishing car and van-pool programs. Van-pools are a form of para-transit (note the substitution of terminology from Table 5 of Brief No. 3). Vans are leased by the employer or employee from private business depending on the program and available budget. The riders in the pool pay for the full cost of operation through fares. Successful vanpool programs have been implemented in various Bay Area locations.

bicycle systems - This measure assumes that a one-half mile grid system of bicycle lanes is imposed on existing streets over an area of approximately 1100 square miles of developed land. This comes to approximately 4400 miles of bicycle lanes which would be established in the period, 1980-85. Planning would commence in 1978.

Land Use/Development Control Measures[4]

Two land use strategies have been developed to evaluate the effect of land use/development controls on air quality by the year 2000. It is assumed that the impact of land use policies in development patterns and air quality would be incurred over the long term and would not be measurable until 2000. The first land use scenario analyzed assumes:

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[4] Developed by the Association of Bay Area Governments (ABAG)

- o slow population growth trends
- o current land use policies applied in 1977-2000

The second scenario assumes:

- o slow population growth trends
- o compact development policies applied in 1985-2000
- o the transportation control measures documented above

The terms slow population growth refers to a slower rate of regional growth than currently exists. It might occur as a result of declining birth rate, declining migration rate or other factors such as limited sewage treatment capacity, etc. The slow growth trend represents projections and not goals. There are no specific measures aimed at achieving these projections.

The measures for land use control are directed toward the goal of more compact development. A total of 46 control measures have been proposed to achieve the following objections:

- o to reduce long distance auto commuting
- o to reduce the number of auto trips and increase transit usage
- o to increase the efficiency of transportation systems to service land as it develops

A forthcoming report will document how land use strategy assumptions are reflected in regional population, employment and housing totals and how they are translated into air quality impacts.

II. CONTROL MEASURE EFFECTIVENESS

Control measure effectiveness has been determined by a variety of methods including computer modeling, surveys, research results, documented experience and professional judgment. Detailed descriptions of the modeling techniques are contained in Issue Papers 1 and 2 and Tech. Memos 1, 2 and 7.

The estimates of effectiveness, presented in Table 1, are given in terms of tons of pollutant per day that are reduced from the baseline emissions given in Technical Memorandum 11. The emissions reductions documented in this report are for five pollutants: particulates, hydrocarbons (HC), nitrogen oxides (NOx), sulfur oxides (SOx) and carbon monoxide (CO). Emissions reductions for oxidants (produced by the combination of NOx and HC in sunlight) are analyzed via the LIRAQ model. Results from the LIRAQ modeling process will be presented in a future report. Estimates of effectiveness are not additive because in some cases, the controls overlap i.e. apply to the same source categories.

TABLE I:

CONTROL EFFECTIVENESS AND COST

CONTROL	1985 EMISSIONS REDUCTION (TONS/DAY) HC	NOx	CO	SOx	PART	2000 EMISSIONS REDUCTION (TONS/DAY) HC	NOx	CO	SOx	PART	COST[b] CAPITAL	O/M[e]	A/R[e]	EXPLANATION
STATIONARY SOURCES[a]														
• HIGH SOLIDS & WATERBASE COATINGS	60	—	—	—	—	80	—	—	—	—	$58M	$3M	—	PRIVATE SECTOR COSTS TO ACHIEVE 1985 REDUCTION
• CLOSED SYSTEM ORGANIC STORAGE	40	—	—	—	—	65	—	—	—	—	$150M	$7.5M	—	"
• LIMIT MAX. SO_2 TO 300 PPM OR EQUIVALENT MASS	—	—	—	40	—	—	—	—	50	—	$41M	$2.1M	—	"
• LIMIT FUEL SULFUR CONTENT TO .25% OR THE EQUIVALENT STACK GAS CONCENTRATION	—	2.8	—	94	—	—	3.7	—	57	—	$480M	$25M	—	"
• BEST AVAILABLE CONTROL TECHNOLOGY FOR NEW AND EXISTING SOURCES	231	77	—	211	46	344	74	—	211	53	$1,240M	$66M	$.5M	INCLUDES REDUCTIONS AND COSTS OF FIRST FOUR MEASURES.
• NEW SOURCE REVIEW (AS IS OR MODIFIED)	NOT ESTIMATED SEPARATELY; PARTIALLY INCLUDED UNDER BACT													
MOBILE SOURCES														
• MORE STRINGENT LIGHT, MEDIUM DUTY VEHICLE EXHAUST STANDARDS	NO SHORT TERM IMPLEMENTATION ASSUMED					41	24	1191	—	—	$800M	($200M)[d]	$40,000	EQUIVALENT TO $300/VEHICLE CAPITAL COST AND $500/VEHICLE, O/M SAVINGS OVER VEHICLE LIFETIME
• MORE STRINGENT HEAVY DUTY VEHICLE EXHAUST STANDARDS	NO SHORT TERM IMPLEMENTATION ASSUMED					21	47	526	—	—	—	—	—	INCLUDED IN ABOVE COST
• INSPECTION/MAINTENANCE PROGRAM FOR LIGHT DUTY VEHICLES	23	—	749	—	—	49	—	1196	—	—	$5.3M	$14.7M	$2.5M	FOR A PROGRAM COMMENCING IN 1982; A/R COSTS ARE EXPENDED BY AIR RESOURCES BOARD; EQUIVALENT TO APPROX. $5/VEHICLE/YEAR.
• INSPECTION/MAINTENANCE PROGRAM FOR HEAVY DUTY VEHICLES	NO SHORT TERM IMPLEMENTATION ASSUMED					9	—	166	—	—	—	—	—	INCLUDED IN ABOVE COST
• EXHAUST RETROFIT FOR HEAVY DUTY GASOLINE TRUCKS	25	—	812	—	—	—	—	—	—	—	$20M[a]	—	$100,000	EQUIVALENT TO AN AVERAGE CONSUMER COST OF $340 PER VEHICLE FOR THE CONVERTER
TRANSPORTATION[a]														
• TOLL INCREASE	.2	.2	3.1	—	—	COMBINED WITH COMPACT DEVELOPMENT SCENARIO IN 2000								
• REGIONAL PARKING STRATEGY	—	—	—	—	—						—	5.3M	—	ADDITIONAL TOLL CHARGES IN 1979-80
PARKING TAX	.3	.2	3.9	—	—			"						
ELIMINATE FREE EMPLOYEE PARKING	.9	.8	13.3	—	—			"			—	6.9M	$17,000	
PREFERENTIAL PARKING TO CAR, VAN POOLS	.1	<.1	1.5	—	—			"			—	20M	30,000	ANNUAL PARKING CHARGES
• ADDITIONAL TRANSIT SERVICES	.7	.7	11.2	—	—			"			—	$1M	30,000	
• BUS/CARPOOL LANES WITH RAMP METERING	.2	.2	2.4	—	—			"			$517M	$18.5M	—	COST OF 500 ADDITIONAL BUSES
• AUTO-CONTROL ZONE IN SAN FRANCISCO CBD	.1	.1	2.3	—	—			"			$139M	—	—	
• ENCOURAGE RIDE-SHARE SYSTEMS	1.7	1.2	20.4	—	—			"			$123,000	$134,000	—	COST OF DIVERTERS AND SIGNAL MODIFICATIONS
• BICYCLE SYSTEMS	2.0	0.8	31.9	—	—			"			—	—	$300,000	
											$10.1M	—	150,000	

TABLE 1 (CONTINUED)

CONTROL EFFECTIVENESS AND COST

CONTROL	1985 EMISSIONS REDUCTION (TONS/DAY) HC	NOx	CO	SOx	PART	2000 EMISSIONS REDUCTION (TONS/DAY) HC	NOx	CO	SOx	PART	COST CAPITAL	O/M[e]	A/R[e]	EXPLANATION
LAND USE														
• SLOW GROWTH & EXISTING LAND USE POLICIES	NOT IMPLEMENTED IN SHORT TERM					59.1	30.4	697	6.0	18.6				
• SLOW GROWTH & COMPACT DEVELOPMENT POLICIES & TRANSPORTATION CONTROLS	NOT IMPLEMENTED IN SHORT TERM					84.3	56.5	1144	9.4	23.4				

NOTES:

a. 1975 DOLLARS
b. 1977 DOLLARS EXCEPT WHERE NOTED
c. M = MILLION
d. SAVINGS OR REVENUE
e. O/M = ANNUAL OPERATING AND MAINTENANCE, A/R = ANNUAL ADMINISTRATIVE AND REGULATORY

Additional, ongoing analyses model cominations of control measures, or strategies. The results of these analyses will be the subject of a future report.

A brief explanation of the methodology for estimating control effectiveness is given in the following paragraphs. If further information is desired, inquiries should be directed to: BAAPCD for stationary source controls, MTC for transportation controls, ARB for mobile source emissions controls and ABAG for land use controls and for general questions.

Stationary Source Controls

Estimates of effectiveness were based on an evaluation of the number, type and size of industrial sources that would be affected by the proposed measure, the control equipment or process that would be required and estimates of the equipment or process efficiency. Factored into these estimates were assumptions on expansion rates, ease of plant modification and expansion, the availability of fuel and plant modification schedules. New source review was not assumed to be in effect. For some of the source categories for which BACT was defined, the control technology has not been proven on a commercial basis in California or in the U.S. (e.g. NH_3 injection).

If the state of the control development is sufficiently advanced that commercial applications is highly feasible by the 1980's then the control is included. It should be noted that there is no consensus among "experts" for a uniform definition of BACT.

Mobile Source Emissions Control Measures

Control effectiveness was derived by identifying the vehicle classes that would be affected (i.e. by year of manufacture and by type of vehicle), estimating the size of that vehicle subpopulation in the Bay Area and estimating the average per vehicle mileage. Emissions reductions were computed by applying the difference in emissions rates (i.e. existing minus proposed) to the total mileage incurred by the vehicle category.

Transporation Control Measures

The estimation of transportation control measure effectiveness was based on a model that simulates the travel mode choice decision-making process of an individual. In this model, the individual is assumed to have a choice of three modes of travel: drive alone, transit or shared ride (drive + passenger). Extensive studies and emperial evidence have shown that certain variables greatly determing the individual's choice. These are:

- o the access time to the mode from the origin
- o the total travel time = the wait time for the mode + travel time + transfer time
- o the access time from the mode to the destination
- o the out-of-pocket cost

Each of the transportation control measures (except bicycle systems) are translated into an effect on one or more of the above variables. The model estimates the number of riders who would switch to transit or shared-ride. These are translated into the number of vehicle miles of travel that are not made as a result of the switch and thence the amount of pollutants reduced. Only home-based work trips were examined because they are the most susceptible to model services influences.

The effectiveness of a bicycle system in reducing vehicle miles traveled, and thereby vehicle-emitted pollutants, was derived from a report prepared for by Barton-Aschman.[5] This control measure yields the greatest single measure pay off because it assumes an extensive system of bicycle lanes and would induce mode switching from other types of trips besides home to work, i.e. shopping, recreational, social and off-peak.

Land Use Control Measures

The effectiveness of land use controls is measured in terms of the number of vehicle-miles of travel (VMT) that are prevented due to increased transit usage and reduced vehicle usage. Technical Memorandum 2 describes in detail the modeling process for determining the impact of slow growth and compact development on VMT.

III. CONTROL MEASURE COSTS

The control costs described in this report refer to the direct monetary cost of implementation. They represent best estimates based on the costs of similar applications in California and other areas, literature reports, surveys[6] and communications with industry.

Estimates are given for three source categories:

- o capital - the cost of land, structures, equipment, equipment replacement, research and design engineering, planning, administrative and legal services involved in capital investment.
- o operation and maintenance - the annual costs of energy, labor, parts, materials, overhead, repair of equipment and structures for operations and maintenance of capital equipment.
- o administrative and regulatory - the cost of enforcement, planning, public participation, coordination with other agencies or firms, monitoring and data evaluation costs. These are generally incurred by the public sector or by the regulatory agency implementing/responsible for the measure.

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5 Ohrn, et al, "Framework for Investing in Urban Bicycle Facilities", Barton Aschman & Associates, published in Transportation Research Record 508, 1974

6 Technical Memoranda 8, 9, 10

Although cost estimates are given in 1975 and 1977 dollars, depending on the source of information, all costs will be updated to 1977 dollars for the purpose of control evaluation across all environmental management plans. Inflation is not included in these estimates in order to enable comparability of control cost-effectiveness.

Estimates of the stationary source air pollution control costs are subject to considerable uncertainty, depending on the specific controls being analyzed. The degree of accuracy varies with the data source. At best cost estimates may be 50 to 100% lower or higher than actual costs for some of the following reasons:

- best available control will vary from expert to expert and will certainly change during the period covered in this study.
- predicting the cost of BACT and process changes for degrees of industrial categories and thousands of individual companies which vary greatly in size, ease of modification and expansion, complexity of process and status of air pollution control--can only be termed best guess.

The indirect costs of control such as the resultant increase in the cost of consumer goods and services are treated in a separate memorandum which assess the overall social, economic and environmental impacts of control.

IV. SUMMARY

The estimates of control measure effectiveness show that the most effective controls are also the most costly, i.e., "you get what you pay for." The question of who pays is clear from the type of controls enumerated in the report. Stationary source controls are borne by private industry although these are eventually passed on to the consumer. Land-use control costs are primarily social and are borne by the public in the form of increased housing costs, limited options for residential locations, etc. Mobile source emissions controls, on the other hand, yield substantial emissions reductions (of CO and HC) for a relatively modest per vehicle cost. The total cost appears high when applied to the total projected vehicle population.

Transportation controls appear to yield relatively small gains only because they address a portion of the total trip-making activity in the region--the home-to-work trip.

ATTACHMENT A: Best Available Control Technology[a]

Source Category	Pollutant	Best Available Control
Petroleum Refining		
o refining processes	particulate	3-stage electrostatic precipitator
	SOx	desulfurization of crude
	NOx	desulfurization of crude
o other processes	fugitive organic	improved maintenance programs use
	fugitive dust	special sand aggregates in sand blasting operations
o upsets, breakdowns, flaring	particulate organic	improved maintenance and process change; compressors, piping, additional surge vessels, instrumentation
Chemical		
o nitric acid plants	NOx	NH_3 injection (already constructed at Chevron)
o sulfur plants	SOx	sulfur recovery units
o sulfuric acid plants	particulate	sulfur recovery units
	organic	sulfur recovery units
o miscellaneous chemical processes	particulate	water injection, by hydroblasting use of certified abrasives starved air combustion and afterburner baghouse
	organic	incinerator low-no solvent coatings
Other Industrial/ Commercial		
o pulp and paper	all	improved maintenance and process changes
o metallurgical	particulate	loading door assembly (tar pots) baghouse, venturi scrubber incineration (cable tar coating)
o mineral	particulate	water spray system with wetting agent
	SOx	

[a]Developed by W. Crouse, Bay Area Air Pollution Control District

Source Category	Pollutant	Best Available Control
o M-concrete batch	particulate	baghouse
o M-glass, etc.	particulate SOx	improved maintenance and process changes
o M-stone, sand, etc.	particulate	water-spray system with wetting agent, water injection
o M-sandblasting	particulate	water injection, hydroblasting use of certified abrasives
o other mineral	particulate	baghouse, venturi scrubber shrouding, water injection, hydroblasting, use of certified abrasives
o food-agricultural processing	particulate organic	baghouse, electrostatic precipitator, scrubber with incineration, chlorine injection and chemical scrubber, starved air combustion plus afterburner, loading door assembly
o paint spray mist	particulate	improved maintenace and process changes
o wood products mfg.	particulate	starved air combustion and afterburner, baghouse, incinerator, low-no solvent coatings
o other industrial/ commercial processes	particulate organic	baghouse, precipitator, scrubber with incineration, chlorine injection and chemical scrubber, starved air combustion and afterburner
Petroleum Refinery Evaporation		
o storage/blending	organic	closed-system organic storage
Other Organic Compounds Evaporation		
o industrial coating o commercial/domestic coating	organic	low solvent (i.e., high solid, water base coatings)
o degreasers	organic	solvent recovery, e.g., carbon adsorption
o dry cleaners	organic	solvent recovery, e.g., carbon adsorption

Source Category	Pollutant	Best Available Control
o dry cleaners	organic	solvent recovery
o rubber fabrication	organic	solvent recovery
o plastic fabrication	organic	solvent recovery
o prenting	organic	solvent recovery
o other organic evaporation	organic	solvent recovery
Combustion of Fuels		
o oil refineries (6)	NOx	retrofit for off-stoichiometric combustion and/or flue gas re-circulation
		desulfurization of crude, new sulfur recovery units with tail gas units
o power plants-oil fired -coal-fired		NH_3 injection, combustion modi-fications
	SOx	desulfurization of crude (in re-fineries) flue gas desulfurization
o other industrial combustion	NOx	combustion modification
	SOx	desulfurization of crude (in re-fineries)

AQMP/Tech Memo 15 January 1978
Assessment/Evaluation Tech Memo 4

ASSESSMENT OF AIR POLLUTION CONTROL PROGRAMS

INTRODUCTION

The impacts of the various air pollution control measures are summarized in this technical memorandum. The proposed list of possible measures is divided into four groups with a different agency having prime responsibility for assessing each. Stationary sources were examined by BAAPCD, mobile sources by ARB, transportation controls by MTC and development and land use management by ABAG. The controls vary considerably in their specificity and probable application. In addition, the actual controls could be bundled in an almost endless series of combinations, all having substantially different costs and impacts. To simplify the assessment, the four control measure groups were kept separate. Major cross effects are noted, however.

The Assessment Process

The assessment factors considered are organized into four broad categories--Environmental, Institutional and Financial, Economic, and Social. Within the four broad categories 66 potential impact issues were examined in 14 subject areas as follows:

- Environmental
  - I. Water Quality and Quantity
  - II. Physical Resources (ecological habitats, agricultural land, etc.)
  - III. Energy
  - IV. Amenities (scenic, cultural, recreational)
- Institutional and Financial
  - V. Institutional (inter-agency coordination, etc.)
  - VI. Financial (public works, taxes, etc.)
- Economic
  - VII. Production of Goods and Services (employment, etc.)
  - VIII. Income and Investment (land, capital requirements, etc.)
  - IX. Consumer Expenditures (transportation costs, goods and services, etc.)

*This memorandum updates and expands upon the draft AQMP Technical Memorandum 15 of September 12, 1977. Unlike the draft, it assesses policies recommended in the draft Environmental Management Plan.

Social

X. Housing Supply (existing and new)

XI. Physical Mobility (auto and transit convenience)

XII. Health and Safety

XIII. Sense of Community (character, stability)

XIV. Equity (low income, minorities, etc.)

Air quality impacts measured in tons/day and direct costs of implementation are discussed in Technical Memorandum 14, "Effectiveness and Costs of Alternative Air Pollution Control Programs". No weighting of importance is implied in the organization of the remainder of the assessment factors listed above or in the type of information presented. Where possible the assessment is quantitative. In many cases, the qualitative judgment of staff appears where specified data ("hard" numbers) are not available. Most major assumptions used in the quantitative and qualitative analyses are noted. Other detailed assumptions are in separate documents, such as Series 3 Provisional Projections. In some cases, the magnitude of the potential problem is indicated and the locations or conditions where it would most likely occur are noted. Further examination and monitoring would be undertaken during the AQMP continuing planning process.

STATIONARY SOURCE CONTROLS

Five control measures are proposed by the BAAPCD to minimize hydrocarbon emissions from stationary sources:

1. Use of paints and other coatings that are water-based and/or have a high solids content.
2. Use closed systems for storage and transfer of organic liquids.
3. Use Best Available Control Technology (BACT) on new and existing hydrocarbon sources.
4. Continue the review of new and modified industrial and commercial facilities (new source review)

Stationary Source Controls Would Impact Physical Resources

Between 18,000 and 25,000 gallons per day of organic solvents could be conserved by implementing the proposed organic solvent controls.

Best available control technology (BACT) would consume construction materials, water and use disposal facilities in the manufacture, construction and operation of the equipment and processes involved. However, BACT comprises many things and has not been explicitly defined with regard to all Bay Area industrial operations. Consequently, more detailed impacts assessment requires further definition of BACT.

Reduced hydrocarbon emissions would reduce the damages to vegetation that result from photochemical oxidants. Trees, shrubs and many agricultural crops in the Bay Area are affected by the oxidant levels which occur here. Adverse effects include visible injury and discoloration of foliage, leaf drop, reduced plant vigor and growth, and total plant loss. Certain crops are no longer grown here (snap dragons, chrysanthemums) and others evidence serious damage (grapes, carnations, orchids). Crops such as grapes and ornamental plants are specialty crops grown in few other parts of the country. They are an important component of the region's economy. To realize their productive value, certain specialty crops such as cut flowers must be grown in locations proximate to urban areas. Many Bay area ornamental growers have moved to Half Moon Bay and Salinas to avoid air pollution damage. Improved air quality would ensure the viability of these crops and this important sector of the Bay area economy.

Stationary Source Controls Would Impact Energy Resources

Use of best available control technology for hydrocarbon emissions, use of high solids/water base coatings and closed systems for organic liquid storage should not result in net energy losses. Technologies such as industrial water-based coatings and solvent incineration are energy consumptive. High solids coatings and improved vapor recovery systems produce energy savings.

Stationary Source Controls Would Impact Amenities

The principal impact of the stationary source actions would be their contribution toward the improvement of air quality in the Bay Area as reduced amounts of hydrocarbons are available for reaction with other gases to form photochemical aerosols.

Stationary Source Controls Would Impact the Production of Goods and Services and Income and Investment

Increased dependence by the Bay Area industrial sector on technological approaches to improving air quality will require substantial amounts of capital investment. In recent years, capital investment for pollution control equipment has been between 2% and 10% of total business investment. Since 1975, when the percentage peaked at 10%, the portion of investment for pollution control versus total capital investment has been declining. Studies by Chase Econometrics and McGraw-Hill suggest that the ratio will continue to decline until a new equilibrium or long-term average is achieved. Based on these studies, it is estimated that the 1977 investment in pollution control equipment of about 7% of total capital investment will decline and in the future represent about 4% of total investment. Programs such as the California Pollution Control Financing Authority and the Small Business Administration (SBA) Loan Program provide some aid in financing pollution control investments. Current Federal government tax incentives (tax exempt bonds for pollution control equipment) also partially offset the capital costs associated with installation of pollution control equipment.

Improvements in air quality can often also be affected by changes in production processes. Such approaches, while not without cost to the industry, are generally less costly than technology-based, retrofit alternatives. The benefit of production process changes is the potential for such changes to result in efficiency gains, increased productivity and production cost savings. In some cases, process changes could be necessary to meet emission reduction requirements. The paintings and coatings industry for example produces products to specification. In order to produce to specification, some changes in product composition might be necessary. The actual effect cannot be estimated, but one result could be reduced durability of the product and increased liability.

The employment effects of stationary source controls will vary from industry to industry and within industries. Actual impacts require a case by case assessment especially as BACT is further defined. In some cases, the cost of pollution control equipment for certain firms could be beyond their ability to finance and still remain competitive. Programs such as the SBA Loan Program were designed to mitigage against severe repercussions which could result in firms leaving the market place. However, these programs are limited.

Increased production of pollution control equipment may increase the number of jobs in that sector. Manufacture of pollution control equipment is not a component of the region's economic base. Product design, sales, installation and maintenance is a component of the regional economy and a small number of jobs in those aspects of the pollution control equipment field can be expected.

The new source review regulations can be expected to have a minor impact on total economic development in the Bay Area. Regional employment, in the absence of new source review regulations, is projected to reach 2.85 million by the year 2000 from a 1975 base of 1.95 million total wage and salary employment. Under the existing new source review regulation, employment is expected to be 2.81 million by the year 2000, a difference of about 2% or 40,000 jobs. Those 40,000 jobs are not jobs lost (i.e. it does not represent 40,000 people who would lose their jobs) but rather reflects the fact that there could be 40,000 fewer new jobs than might be expected absent current new source review regulations. These figures were developed using the assumption that the new source review rule was in place only in the Bay Area and not in other parts of the country. As that is not expected to be the case, the estimated impacts overstate the effects.

Not all industries would be affected by new source review regulations. Two factors determine the magnitude of the impact--the anticipated rate of growth in the particular industry (i.e. certain sectors are experiencing a decline in economic activity) and the type of pollutant emissions associated with the particular industry. Some industries won't be affected at all. The emissions from some plants are not expected to be significant so that a permit to operate could be issued. In other cases, installation of control equipment to meet the EPA new source performance standards or the BAAPCD odor standard would allow the source to meet the new source review rule requirements.

The industries which are expected to be affected are chemicals and allied products, primary metals and transportation equipment manufacturers. Impacts in these basic sector industries will have secondary effects on the service sector (e.g. transportation, public utilities, wholesale and retail trade, finance, insurance and real estate, government and direct services). About 61% or 26,500 of the reduction in projected new jobs by the year 2000 would occur in the service sector while 16,700 of the new job reduction would occur in the manufacturing sector. The crafts, equipment operation and transport operation categories would experience almost 1/3 of the reductions in new jobs. This is largely a function of their role in the manufacturing industries affected by the new source review rule.

A relatively small number of jobs will be directly generated in the Bay Area as a result of the new source review rule. These jobs are basically in the design, installation and maintenance aspects of pollution control equipment.

Stationary Source Control Could Impact Consumer Expenditures

The direct costs of implementing the stationary source controls would be borne by the private sector. Many of the capital costs would be passed on to the consumer in the form of higher prices for goods and services. Higher prices for Bay Area products could place those products at a competitive disadvantage outside the region, assuming comparable price increases for similar reasons would not occur elsewhere. Process changes

to achieve emission reductions may result in production efficiencies if not in actual increased productivity so that in some cases controls may not result in higher product prices. Consumers may view the costs of implementation as an investment having non-economic but valuable returns in improved air quality and associated benefits.

Stationary Source Controls Would Impact Health and Safety

Air quality standards are based upon scientifically derived air quality criteria. Those criteria are an expression of current information about the relationship between various concentrations of pollutants in the air and their deleterious effects on humans and the environment. Photochemical oxidants have been found to cause eye and nasal irritations, irritation of mucous membranes, respiratory distress, coughing, increased lung fluid, rapid pulse rate, lowered blood pressure, asthma attacks and overall decreases in the quality of human performance. Reductions in hydrocarbons and thus exposure to photochemical, oxidant and ozone concentrations will reduce these potentially adverse effects. The benefits would be particularly significant for sensitive population groups such as the elderly, children and the chronically or temporarily ill.

The health effects of air pollution on children is a subject receiving increased attention. Children may be more vulnerable to irreversible health damage caused by air pollution than any other age group. According to a recent staff report by the California Air Resources Board*, numerous studies indicate that pollutants can impair lung development in children and cause permanent loss of usable reserve lung capacity for later life. Pollutants can also reduce the effectiveness of the body's immunity to diseases and cause lung tissue to "age" prematurely. The effects of continued exposure to low levels of pollution can cuase life-long damage before it can be detected. Children are more sensitive to air pollution because their respiratory systems are just developing and because children exchange two to eight times more air in relation to their body weight by breathing faster than adults.

The study indicates, for example, that air pollution levels may account for 16.7% difference in respiratory symptcms between different schools in the Los Angeles area. The schools with the highest level of respiratory disease were located in the San Fernando and Pamona Valleys which are known for the high oxidant concentrations (frequently exceeding the Stage 1 episode of 0.20 parts per million).

Cuprent air quality standards are based in whole or in part on adverse health effects of air pollutants upon healthy adults. To protect children from the harmful effects of air pollution, the ARB says stronger air quality standards might have to be established.

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*California Air Resources Board Bulletin, Vol. 8, No. 8, Sacramento, California, October-November 1977.

The general population should also benefit from emission reductions. Although the long-term exposure effects from moderate levels are not as easily observed as those from short-term exposure to high levels of pollutants, reduced emissions and concentration levels should have overall beneficial health effects.

The stationary source control program may also eliminate or greatly reduce many safety hazards associated with the use and storage of combustible solvents.

Stationary Source Controls Could Have Equity Impacts

Equity effects could be associated with stationary source controls. One effect discussed here as an equity effect differs from the definition of equity used for the assessment of the Environmental Management Plan (See Equity introduction of development and land use controls section of this Technical Memorandum). That effect is the impact of stationary source controls on the competitive position of Bay Area industries. The issue of whether the restrictions and controls recommended for the stationary source portion of the AQMP would place Bay Area industries at a competitive disadvantage turns on requirements for similar measures elsewhere by the U.S. Environmental Protection Agency and the California Air Resources Board.

Other equity effects of the stationary source controls revolve around the issue of the indirect effects of controls on special population groups such as the low income, minorities, youth, the elderly, and the handicapped. Many of these groups reside in the highly urbanized areas of the region. Those areas experience significant oxidant concentrations and thus residents there are often subject to exposure to those concentrations. Reductions in emissions should reduce resident exposure to higher oxidant concentration levels and thus reduce the deleterious effects of exposure (see Health and Safety discussion for deleterious health effects associated with oxidants).

Another equity issue is the employment effects of stationary source controls as they impact special population groups. A detailed analysis of the employment effects of the entire stationary source control program would be necessary in order to assess whether special population groups would be particularly impacted by potential employment effects. Analysis of the new source review rule employment effects (using assumptions noted previously) indicates that the uneven distribution of occupational impacts could cause an uneven distribution of the impacts across minority populations. Blacks represent 7% of the Bay Area's labor force, but it is projected that 9% of the employment effects of new source review would affect them. The effect of the employment impacts on whites and spanish speaking people is not projected to be as great as their proportion of the total labor force. Whites represent 82% of the labor force and 81% of the employment impacts would affect them. Spanish-speaking people represent slightly more than 11% of the region's labor force but slightly less than that percentage of the employment affected by new source review.

MOBILE SOURCE CONTROLS

These control measures are proposed by the ARB to minimize hyrdocarbon emissions from motor vehicles:

1. A more stringent light and heavy duty exhaust control program seeks to reduce emissions by 50 percent from the 1977 presecribed levels. This program would require development of new engine technology.

2. The Bay Area would establish a motor vehicle inspection/maintenance program.

3. Heavy duty gasoline vehicles would be required to install catalytic converters, and these vehicles would consequently burn unleaded fuel.

Mobile Source Controls Would Affect Physical Resources

No significant impact on physical resources is expected from more stringent exhaust emission controls where these controls can be achieved by further technological improvement of conventional vehicle engines. However, if new engine designs requiring alternative fuel sources are pursued to achieve this measure, then new materials may be required to manufacture these engines. For example, electrically powered vehicles may require special material to construct batteries capable of providing satisfactory performance. Of greater significance in effect on physical resources is the possibility that new engine technologies will use less specialized fuels, thereby reducing dependence on gasoline or petroleum per se.

Mobile Source Controls Will Produce Significant Energy Savings

Significant energy savings will be produced by improved maintenance of engines and emission control systems, as well as through the eventual development of new engine technologies. The inspection and maintenance program and the retrofit program for heavy duty gasoline trucks could save approximately 10 million gallons of gasoline annually, and new engine technology could eventually improve vehicle mileage, which in turn would mean annual savings of millions of barrels of oil.

Institutional Changes Would Be Required by Mobile Source Controls

New legislation would be required for the California Air Resources Board to implement both the inspection/maintenance program and the heavy duty gasoline retrofit programs. Because such legislation is not likely in the current session of the legislature, it is not likely to be fully implemented until 1985. Data from a pilot inspection/maintenance program currently being implemented in the South Coast Air Basin suggest that the operation of such programs might make disproportionate demands on the administrative resources of the State. Therefore, a private-operated, public-monitored program may be preferable for the Bay Area.

Production of Goods and Services Would Be Impacted

A slight increase in the production activity of some industries servicing the automobile manufacturing industry might occur as new tooling required to produce newly designed engines is needed. New design may stimulate substantial change in the automotive repair and service industry. The inspection/maintenance measures would add a new line of service for the State's automotive service industry. While some services presently exist for identifying defective emission control equipment on cars, the inspection/maintenance program would offer a universally applied service program for identification and repair of vehicles with excessive emissions caused by maladjusted or defective emission control equipment.

Consumer Expenditures May Be Affected by Mobile Source Controls

The manufacture of new engine technologies would necessitate an increase in the initial cost of new vehicles. This increase may be offset, however, by savings in operating costs throughout the life of the vehicle. Catalytic converters are estimated to costs about $350 per heavy duty vehicle. Inspection and maintenance of light and medium duty vehicles would require a fee of $5-6 per vehicle. The average cost of repairs for the catalyst required vehicle would be about $45.

Physical Mobility Would Be Affected by Mobile Source Controls

Increasing the cost of automobile use through the required inspection and maintenance programs would tend to limit the mobility of automobile dependent low-income populations, particularly those in non-urban areas. Increases in transit service, however, would tend to offset these effects.

Health and Safety Effects Would Be Beneficial

The mobile source controls would substantially reduce hydrocarbon emissions, as well as carbon monoxide emissions. Since hydrocarbon emissions are a major component of photochemical oxidant--and since the oxidant standard is designed to protect public health--public health improvements would be expected from the implementation of these mobile source controls. Substantial health-related benefits may accrue to those segments of the population that experience the heaviest exposure to carbon monoxide concentrations, where such concentrations are reduced. See Section XII on Health and Safety Impacts of the Land Use and Development Management Controls for additional discussion of this issue.

Mobile Source Controls Have an Equity Issue

To the extent that low-income groups and fixed income groups drive older, more heavily polluting vehicles, they may be slightly disadvantaged by the mobile source controls. These groups may also be affected by the financing mechanisms for regulatory programs. Transit improvements recommended elsewhere in the plan, however, should compensate for these disadvantages, assuming they provide increased mobility to the low and limited income groups.

TRANSPORTATION CONTROLS

The Metropolitan Transportation Commission staff recommends eight actions to reduce motor vehicle emissions through transportation actions to reduce vehicle use. The recommendations are complementary to the land use and development recommendations of the plan. Transit service improvements would make compact development more feasible, while compact development's associated higher densities would be transit-supportive. The recommended actions include:

1. Increased bridge tolls (MTC examined $1.25 peak-hour tolls and $1 off-peak tolls beginning in 1980)
2. A regional parking strategy to discourage private auto use and encourage high-occupancy vehicle use
3. Provision of transit improvements of 20% beyond projected levels by 1985, paid for by bridge toll and parking revenues
4. Increased bus and carpool lanes and ramp metering on
   - o Route 580 from Route 24 to the Bay Bridge
   - o Route 80 from San Pablo Dam Road to the Bay Bridge
   - o Route 101 from San Francisco Airport to Route 280 diamond lane
5. Implement an auto control zone in the San Francisco Central Business District
6. Provide more ride sharing services such as jitneys and vanpools.
7. Develop more extensive bicycle systems.

Energy Savings Will Result from Transportation Controls

Elsewhere in this memorandum, energy savings from implementing measures to reduce automobile travel and provide transit improvements are estimated. Compact growth recommendations, together with transportation improvements, are estimated to reduce vehicle miles traveled. Energy savings of approximately 3 million barrels of crude oil annually are expected, when taking into account reduced gasoline consumption and minor transit-fuel increases.

Consumer Expenditures for Transportation Will Be Affected

Cost increases for operating private automobiles could be expected, with bridge tolls estimated to provide $13 million and parking fees $6 million to support transit service improvements recommended by the plan. The cost falls primarily on the middle income worker, particularly those living in the East Bay suburbs and working in San Francisco. The commuters will pay higher bridge tolls and higher parking costs. The effect on the higher income groups is not expected to be great. The higher commute costs, improved public transit and preferential treatment for car- and vanpooling will tend to shift workers from driver-only occupied vehicles.

Mobility Would Be Affected by Transportation Measures

Additional transit service would increase the mobility of all transit

users. Carpool and vanpool measures would increase travel options for most commuters. Automobile movement would be restricted in the automobile control zone in San Francisco.

Health and Safety Would Be Affected by Transportation Controls

Transportation improvements and the land use measures recommended in the air quality plan are intended to reduce hydrocarbon emissions to meet the Federal photochemical oxidant standard. This standard is set to protect public health. As hydrocarbon emissions are reduced, oxidant formation is impaired and public health should be improved. Public health benefits would be particularly important for special population groups (e.g., low-income, minorities, youth, elderly and the handicapped). Children are particularly sensitive to the deleterious effects of air pollution. See the discussion on Health and Safety Impacts in the section on stationary source controls. A recent screening of Los Angeles children near major freeways and heavy industrial plants showed that 23% of the 1,239 children tested had elevated blood-lead levels as compared with children in other sections of the city. Although it was not indicated what portion of the lead was from inhalation or other sources, similar studies have shown that traffic densities are closely related to blood-lead levels, according to the staff report of the Air Resources Board that review these findings.

DEVELOPMENT AND LAND USE MANAGEMENT

This portion of this technical memorandum summarizes assessment of the potential impacts of the land use development alternative examined and recommended as part of the air quality chapter of the draft Environmental Management Plan. This alternative was termed the "compact growth alternative." Information was compiled on a full range of effects that might be associated with the land use and transportation control measures suggested in the Plan.

Compact growth as recommended in the Environmental Management Plan represents a different pattern of land development than would occur if the land regulation and service policies now in effect in local jurisdictions regionwide continue in force for 15 to 20 years. The Series 3 Projections show that under current local policies and programs jobs and housing in the future will be moving farther and farther apart. This means more and more long-distance commuting, and the distances between homes and jobs will be greater. The compact growth pattern is designed to achieve the following objectives:

- Reduce long distance auto commuting;
- Reduce auto trips and increase transit use.

To achieve reduced auto dependency the compact growth alternative seeks to reverse three fundamental characteristics of development of the last 20 to 30 years:

- Shift the location of growth emphasis from outlying suburbs back to urban areas;

- Provide opportunities to locate new housing and jobs throughout the region in closer proximity and improve the balance of housing and jobs in most jurisdictions;

- Increase permitted densities of new development toward the patterns common in older suburbs of the region.

These shifts in development represent a more precise statement of ABAG's 1970 city-centered Regional Plan and regional growth policies adopted by ABAG in 1973 and 1974. They also reflect the existing and emerging policies of many of the region's local governments.

General Approach of Assessing Compact Development

The Bay region will have more people in the future. ABAG estimates that by the year 2000, the region's population will be between 5.4 and 6.1 million, compared with 4.8 million in 1975 and 4.9 million today. These year 2000 totals were based on estimates of birth and death rates, migration, and the region's share of national economic development. Because there are always uncertainties about these factors, the range of future population was developed to bracket the possibilities

Estimates have also been made about where in the region people will live and work. A reasonable assumption is that development of jobs and homes will occur in accordance with the policies of local governments, especially cities and counties. Therefore, an inventory was made of these policies. They were used to indicate the distribution of the regional totals of 5.4 and 6.1 million. In doing this, it was found that development according to current development policies and service programs would accommodate 5.4 million, but not 6.1 million. Regionwide current local policies and programs would not accommodate projected population growth to the year 2000. If the region grows to 6.1 million, local governments' policies will have to change to support such growth. There would have to be higher densities and/or more unsewered sprawl than is possible under current policies and service programs.

To resolve this, ABAG staff made assumptions about how factors such as infill might be reflected to accommodate the higher population figure. The adjustments were generally toward more compact development after about 1985. This became the Series 3 high projection, generally intended to be a reasonable estimate of how the region would grow to 6.1 million. The low projection is a reasonable estimate of how the region would grow to 5.4 million. The low projection is generally consistent with current local policies throughout while the high estimate reflects other factors beyond 1985. Substantial compact development would be required to accommodate 6.1 million people without considerably more urban sprawl.

This is important for two reasons. First, it means that if the region grows toward the high projection, most cities and counties are going to be faced with the issue of servicing land they now don't plan to serve (which can be interpreted as more sprawl) or higher densities for land now serviced. Second, it means that the effects of compact development, as recommended in the air quality plan, cannot be validly measured against the high population projection because that projection already reflects substantial compact development. If such a measurement were made, it would probably underestimate the effects--both beneficial and adverse.

Therefore, the effects of compact development were assessed for the low population projection, and that is what is presented in this memorandum. This in no way should be construed as an endorsement of the lower population projection by ABAG. Using the lower projection enabled staff to make a more accurate assessment of the difference between long term effects of compact development and a clearer statement of the effects of current programs.

TABLE 1

COMPARISON OF PROJECTIONS
CURRENT PROGRAMS and AQMP COMPACT GROWTH
(x 1,000's)

1990

COUNTIES	OCCUPIED HOUSING UNITS		POPULATION		JOBS	
	Current Programs	Compact Growth	Current Programs	Compact Growth	Current Programs	Compact Growth
ALAMEDA	498.3	537.4	1118.5	1201.2	503.4	503.6
CONTRA COSTA	310.8	281.8	747.2	695.4	195.2	193.2
MARIN	105.1	98.7	257.8	234.3	65.1	63.2
NAPA	36.4	36.1	84.2	84.8	34.0	34.1
SAN FRANCISCO	316.4	320.9	607.0	617.2	586.4	586.8
SAN MATEO	267.3	296.1	623.1	675.5	260.1	260.1
SANTA CLARA	539.3	538.6	1295.9	1276.5	707.1	708.2
SOLANO	111.3	91.6	255.6	223.8	67.2	65.9
SONOMA	133.4	117.0	294.7	275.2	92.3	92.5
REGION	2318.2	2318.2	5284.1	5284.1	2507.6	2507.6

2000

COUNTIES	OCCUPIED HOUSING UNITS		TOTAL POPULATION		JOBS	
	Current Programs	Compact Growth	Current Programs	Compact Growth	Current Programs	Compact Growth
ALAMEDA	520.1	570.6	1114.4	1217.1	507.5	508.8
CONTRA COSTA	324.0	291.6	759.6	690.9	198.8	197.3
MARIN	115.2	102.9	280.7	238.0	62.7	64.3
NAPA	40.1	38.2	90.8	86.5	36.6	36.6
SAN FRANCISCO	331.4	325.3	613.3	606.4	589.8	590.0
SAN MATEO	294.6	318.3	647.9	699.5	263.4	262.3
SANTA CLARA	556.6	583.2	1281.9	1321.0	740.7	743.0
SOLANO	133.5	106.1	289.5	248.0	73.5	71.4
SONOMA	158.1	137.5	340.4	311.1	102.1	101.5
REGION	2473.7	2473.7	5418.5	5418.5	2575.1	2575.1

Source: ABAG

Amount of Growth

The projected county-by-county growth pattern to 1990 and 2000 is indicated in Table 1, comparing housing, population, and job growth in the compact growth alternative with high and low regional trends. Air quality analysis was based on the year 2000 projections and focused on comparisons of the low growth regional trend and the effects of compact growth on that same low growth level.

The total regional growth examined in the compact growth alternative is the same as the low trend for the region as a whole. This total growth is allocated around the region assuming more compact development at the urban fringe, more rebuilding within the cities, and somewhat higher zoning densities than now in force, especially in areas with transit service.

Shift of Growth Emphasis from Outlying Suburbs to Urban Areas

The AQMP compact growth alternative is premised on a shift in the location of new housing growth from the outlying suburban fringe to the existing cities of the region. New housing opportunities that, under current regulations, could locate in outlying suburban locations--and usually at very low density--would contribute to air quality degradation. They would be largely automobile dependent and long distances from job opportunities. Even the close-in development, assuming current zoning, would likely be of such low density as to be dependent on the automobile.

As indicated in Table 2, compact growth assumes 43,000 fewer acres would be developable than under current local programs. This is 13% less acreage overall. While about 62,000 fewer acres would be available in suburban and rural areas--land with development problems (lack of service commitments, steep slopes, etc.)--about 19,000 more acres would be available in urban areas than under current programs.

As a result of the compact growth recommendations on land for development over 90% of new housing potential would be expected to locate in existing cities or close-in areas that can be annexed and provided with city services. About two-thirds of the new housing potential would still be located in newly developing areas, but adjacent to the already built-up areas and at higher densities than currently permitted. About three to five percent of the new housing potential would be located on scattered vacant sites bypassed by the suburban development of recent decades. About one-eight of the new housing potential would involve rebuilding within the cities.

TABLE 2

1975 ACREAGE AVAILABLE
FOR RESIDENTIAL AND ASSOCIATED DEVELOPMENT[a)]
CURRENT PROGRAMS/COMPACT GROWTH

DEVELOPABLE LAND CATEGORY	CURRENT PROGRAMS	COMPACT GROWTH	DIFFERENCE AMOUNT (%)
PRIME[b)]	185,000	204,000	+19,000 (+10%)
Vacant	171,000	171,000	
Infill & Rebuilding	14,000	22,000	
New Commitments[d)]	--	11,000	
SECONDARY[c)]	141,000	79,000	-62,000 (-44%)
Vacant	141,000	79,000	
TOTAL DEVELOPABLE LAND	326,000	283,000	-43,000 (-13%)

Notes:

a) Residential and associated development; streets, public, local commerical, etc. Does not account for industrial development, which is assumed to take the same pattern in compact growth as in current programs.

b) Prime = Land zoned for residential use with urban services existing or committed.

c) Secondary = Land zoned for residential use but with development problems (e.g., no service commitments, steep slope, septic tanks etc.). Compact growth: 79,000 acres assumed not developable until after 1990.

d) New Commitments = 4,000 acres lacking service commitments under current programs. Compact growth assumes new service commitments by 1985.

Balanced Growth in Housing and Jobs Throughout the Region

In order to reduce home-to-work commuting, the AQMP compact growth alternative assumes shifts in housing locations closer to existing and projected job opportunities. Thus, jurisdictions that are most imbalanced in housing and jobs now or in the regional growth trend, would be more

balanced by the year 2000. Marin County, for example, would have more jobs and less housing in the compact growth alternative so as to reduce out-commuting. Northern Alameda County would experience slightly greater job growth and substantial housing growth in the compact alternative so as to reduce in-commuting.

Higher Residential Density Would Be Encouraged

Compact growth is premised upon increasing densities in some locations beyond that currently allowed by local zoning. It does not suggest densities notably higher than now exists on the ground. The problem is that most local zoning densities are premised upon the development patterns of the post-1950 suburban development era. These densities are typically lower than the development of older suburbs like Larkspur and Cupertino. This is especially true in the newer suburban communities.

In some of the older cities there is a trend toward "downzoning" of older developed areas to preserve neighborhood character by excluding new higher density development. New higher density development in or near older neighborhoods can occur while preserving neighborhood identity and bringing greater diversity.

The AQMP suggests increasing densities for new development from a region-wide average (excluding San Francisco) of less than 5 dwelling units per acre (as now planned) to a regionwide average of about 6 dwelling units per acre. This would approach but still be less than the 7 dwelling units per acre that exists on the ground now. Thus, the suggested return to higher densities does not imply massive high-rises. It means more town houses and aprtments and more single-family lots of city size rather than rural estate size.

Table 3, on the following page, shows specific examples of both existing and proposed densities in selected locations--urban and suburban. In compact growth land with services (especially transit) is assumed to develop at somewhat higher densities than under current programs, but not higher than on-the-ground densities. Land without service commitments is assumed to develop at the same density as under current programs except where such land is well within the city service area. In these cases (see Hayward example) services are assumed to be available by 1985 and densities are assumed to increase accordingly.

TABLE 3

EXISTING AND PROPOSED DENSITIES
IN SELECTED LOCATIONS

(dwelling units/net acre)

SELECTED LOCATIONS[a]	DENSITY ON THE GROUND 1975	ESTIMATED DENSITY FOR NEW DEVELOPMENT 1990			
		LAND WITH SERVICES[b]		LAND WITHOUT SERVICES[c]	
		CURRENT PROGRAMS	COMPACT GROWTH	CURRENT PROGRAMS	COMPACT GROWTH
Urban					
Fairfield	8.65	5.68	8.20	4.00	4.00
Hayward	6.20	9.92	9.92	1.44	5.90[d]
Napa	5.14	2.65	4.00	0.21	0.21
Novato	5.08	2.71	4.10	--	--
Petaluma	6.41	4.44	6.20	4.44	--
Pittsburg	6.43	4.28	5.70	1.00	1.00
San Francisco (Western Add'n)	61.00	100.00	100.00	--	--
San Mateo	10.63	5.00	8.70	--	--
Surburban					
Danville[e]	5.29	1.80	3.70	3.50	2.50
Fremont[e]	5.17	5.00	5.00	--	--
Menlo Park[e]	4.54	3.48	4.20	0.40	0.40
Pittsburg (West)[e]	5.67	4.74	4.74	--	--
Pleasanton[e]	4.62	4.30	4.50	7.70	--
Santa Rosa[e]	4.16	1.47	2.17	0.20	0.20
Saratoga	4.25	1.31	2.18	1.01	1.01
Tiburon[e]	4.90	2.40	3.60	1.80	1.80
Vacaville	6.20	5.15	6.20	--	--

a) Selected ABAG analysis areas (440 zones) in locations cited. Not the entire community.
b) Land with sewer and water service either existing or committed in capital programs.
c) Land without sewer and/or water service commitments in capital programs. Compact growth assumes this land not developable until after 1985.
d) Locations where Compact Growth assumes new service commitments by 1985 and thus higher density for new development on this land.
e) Suburban locations with express bus transit service or rail transit service.

I. IMPACTS ON WATER QUALITY AND SUPPLY

This section of the assessment of compact growth examines its potential impact on a variety of water-related issues including: protection of water supply reservoirs in outlying watersheds; the effect on water consumption; the effect on regionwide surface water runoff; and localized problems on surface water pollution.

- Compact Growth Would Preserve Outlying Watersheds Estuarine Systems and Groundwater Recharge Areas

Local water reservoirs accounted for 436 million gallons/day--28% of the regionwide water supply in 1975. Preservation of the watersheds of these reservoirs from urban runoff water pollution is of obvious importance. Surface runoff from urban areas contains far greater concentrations of oil and grease, bacteria, heavy metals and other toxic substances than runoff from rural areas. Thus, urbanization in a water supply watershed could introduce undesirable quantities of these pollutants into the water supply.

A greater problem than the existence of urban development, and its runoff pollution, in a reservoir watershed is the amount and duration of construction activity. Construction on grasslands increases natural erosion rates by a factor of 200. Construction on forestland can produce 2000 times the normal sediment load. Such sediments can severely reduce reservoir storage capacity. Periodic removal is costly--as much as $7.00 per cubic yard--which for a typical reservoir can run well over a million dollars a year.

Nine critical watersheds at the urban fringe were examined to determine if the compact growth alternative, based upon air quality concerns, might also preclude additional urban development in the watersheds, thus protecting these watersheds from surface runoff pollution.

The compact growth alternative could have major effect in five of the nine watersheds.

-- It could limit construction in the watersheds of:

  -- Stafford Lake near Novato
  -- Calero Reservoir near San Jose
  -- Stevens Creek Reservoir near Cupertino

-- It could reduce development pressures in the watersheds of:

  -- San Pablo Reservoir near Orinda
  -- Upper San Leandro Reservoir near Moraga

In four other watersheds at the suburban periphery, local development policy already precludes any urbanization and the compact growth recommendations would augment local watershed preservation efforts:

-- Briones Reservoir near Lafayette
-- Almaden and Guadalupe Reservoirs south of San Jose
-- Lexington Reservoir south of Los Gatos.

- Compact Growth Would Reduce
  Regionwide Surface Runoff

No detailed analysis has been made of the regionwide potential for surface runoff for the compact growth alternative contrasted with the continued assumption of current local policy on land development. However, certain conclusions can be made from the comparison of urban land development with and without compact development. A more compact higher density land development pattern would presumably reduce the regionwide volume of surface runoff due to two factors:

-- More land would be left undisturbed in open space, which can absorb more surface runoff water.

-- There would be less coverage by impervious surface such as streets, rooftops, etc. that increase the volume and velocity of surface water runoff.

The compact growth alternative assumes the adoption of local regulations to defer development of approximately 50,000 acres at the urban fringe. This land could be developed under current local regulations. Due to the higher densities assumed in the compact growth alternative, an additional 90,000 acres would likely not be developed. This is a savings of about one-third of the now vacant land that could be urbanized by the year 2000 under current local regulation.

Estimates can be made of the reduction of impervious surface likely under the compact growth alternative. Based on the estimates of housing type that anticipate fewer conventional single-family units, and more townhouse and apartment units, the amount of ground covered by new residential buildings could be reduced by about 15%, or 3,000 acres. From 5,000 to 8,000 fewer acres would be covered by streets. This potential reduction in impervious surface, in the magnitude of 8,000 to 11,000 acres, is not significant in the regionwide context of 200,000 to 300,000 acres of new development and its associated runoff. However, it may have significance in some specific local drainage basins, now mostly undeveloped, and where new development will be the major surface runoff problem in future years.

- Compact Growth Could Increase
  Localized Surface Runoff in Urban Areas

In the AQMP the increase in density proposed in the compact growth alternative is slight on a locality-by-locality basis. Regionwide it would, at most, result in about 18% of all new units built to be multi-family units, compared to about 9% of all new units under current zoning. It

would not result in a totally different housing type than is already permitted under local zoning[1]. It would make locations already proposed for higher density development, under local zoning, more attractive for development.

It is not established that higher densities per se would mean in increased quantity of surface pollution. Higher residential densities on less developed land would concentrate the given amount of pollutants. If such concentrated pollutants were not picked up (in street sweeping, etc.) they would then be more concentrated in the urban surface runoff in these localities. However, the fact that they would be more concentrated implies that such measures as street sweeping could be more efficient. Furthermore, many higher density developments, such as apartment complexes, can include runoff designs as part of their locally approved plans (and do in many cases). Thus, the surface runoff mitigation measures would become more essential in higher density localities but at the same time more efficient. Such mitigation measures are already part of most local planning procedures.

- Compact Growth Would Lower Consumption Rates of Municipal and Domestic Water Supplies

The compact growth alternative would presumably result in less water consumption due to the higher residential densities proposed. Residential water use constitutes about one-third of total water consumption. While the rate of water use inside the house can be expected to remain fairly constant, the trend toward ever lower densities would make increasing outside water use (e.g., lawn and garden watering) a growing problem. The compact growth alternative could reduce this segment of water consumption by about 3% from a year 2000 figure of about 1790 mgd to about 1730 mgd.

[1]See discussion of shift in type of new housing units in Section X.

II. IMPACTS ON PHYSICAL RESOURCES

This section of the assessment of the compact growth alternative examines the potential effect a more compact and higher density land development pattern would have on a wide variety of physical resource issues, including:

- "environmentally critical areas" such as ecological habitats, historical and archaelogical sites, bayside and coastal development, and land capability (slope, flood and earthquake)

- agricultural land

- flora and fauna

- extractive resources (mineral, timber and geothermal energy)

- public development sites (e.g., airports, parks).

• Compact Growth Could Preserve Critical Environmental Areas

Since the compact growth alternative is premised on concentrating development in urban areas, more dense development in the suburbs and deferring or precluding development in the rural areas, it would support efforts to preserve outlying wetlands, marshes, and estuaries. Preserving these habitats is often a matter of minimizing development not only of the sites but also their vicinities.

Generally, compact growth would support the preservation of water-related habitats (salt and freshwater marshes and wetlands, coastal and delta estuaries). This would be especially true of those areas not now close to urban scale development but where development projects are occasionally proposed:

-- Baylands of Contra Costa, Alameda and Santa Clara counties;

-- Suisun Marsh, Carquinez Straits, Delta areas of Solano and Contra Costa counties;

-- North Bay, Napa and Petaluma River marshes;

-- Coastal wetlands and estuaries in Sonoma, Marin and southern San Mateo County.

In some cases water-related habitats lie within or very near cities. These areas are often prime for urban development due to existing or committed urban services. In such cases compact growth may tend to increase development pressure, necessitating closer scrutiny by the local or State agencies (BCDC, Coastal Commissions) having permit and other regulatory authority. Examples would include:

-- Urban north coastal area of San Mateo County. The compact growth alternative would tend to encourage development within serviceable areas of Daly City and Pacifica, and to some extent Half Moon Bay. Coastal Commission and local agencies plan and permit procedures would be affected.

-- Richardson Bay and San Pablo Bay fringes in Marin. The compact growth alternative would tend to encourage higher density development in areas already proposed for development in or near Sausalito, Tiburon and San Rafael. BCDC and local agencies plan and permit procedures would be affected.

Historical and Archaeological Sites are found throughout the region. The 818 State designated historical sites are concentrated in the urban counties where compact growth would tend to increase development pressure on those sites within or very near the cities. More than two-thirds of the historical sites are in San Francisco, Alameda, San Mateo and Santa Clara Counties where compact growth would concentrate more than two-thirds of the new housing in the next 25 years. Current local development policy would concentrate slightly more than one-half of the new housing in these already urban counties.

The 2,340 State designated archaeological sites are not distributed in such a way that they are threatened by urbanization. Almost two-thirds of the archaeological sites are in the less urban north bay counties of Marin, Sonoma, Napa and Solano, where concentrating new development in or near the existing smaller cities will support their preservation.

As already discussed with respect to water-related wildlife habitats, the compact growth alternative would encourage bayside and coastal development in:

-- Urban north coastal San Mateo County; and

-- Urban bayside areas on Richardson Bay and San Pablo Bay in Marin County.

It would discourage such development in:

-- Baylands of Contra Costa, Alameda and Santa Clara Counties;

-- Suisun Marsh, Carquinez Straits, and Delta areas of Solano and Contra Costa Counties;

-- Napa and Petaluma River marshes on San Pablo Bay;

-- Coastal areas of Sonoma, Marin and southern San Mateo County.

Land hazards assessed were earthquake risk, flood plain development, and development on unstable slopes. Compact growth may create pressure for development in some cities where proximity to earthquake fault zones could be a problem. The most significant added concentrations of new housing would be in the following jurisdictions, all of which allow development in areas subject to severe earthquake shaking but which have all adopted the 1973 or 1976 Uniform Building Code that accounts for such hazards: Oakland, Daly City, Millbrae, San Mateo and Mountain View. More than 5,000 additional housing units (greater than current local policy) would be encouraged in areas of San Jose where there should be less severe shaking in an earthquake.

Compact growth policies may create pressure for development in flood prone areas within cities and their service areas. However, likely development shifts in 95 jurisdictions were examined and found to significantly shift development away from such sites in about one-fourth of the jurisdictions. Flood prone areas appeared to be of lesser significance or no significance in about two-thirds of the jurisdictions.

Pressure for development in or near flood plains could result in increased flooding problems in or near five jurisdictions: Concord, Dixon, Petaluma, Rohnert Park, and Sonoma.

The same problem could occur with respect to unstable slope areas within cities. Again, the development shifts that would likely occur assuming the compact growth policies were examined jurisdiction by jurisdiction. Significant development would likely be shifted away from such problem areas in about one-third of the jurisdictions, especially so in Marin and Contra Costa County. The problem appeared insignificant in two-thirds of the jurisdictions. Pressure to develop on unstable slopes could occur in four locations, including Fremont and El Cerrito, and to a very slight degree near Cloverdale and Santa Rosa in Sonoma County.

Even though the regionwide pressure to develop unstable slopes would decrease with compact growth, higher density development may require more extensive grading and therefore lead to more problems on those slopes that are developed. Application of "planned unit development" procedures or more site specific mitigation measures may be called for.

Thus, in terms of land hazards it appears generally that bay region cities can and do avoid such hazards by concentrating development inward, just as most of them did historically before the automobile made such locations accessible.

- Compact Growth Would Reduce Conversion of Agricultural Land

Jurisdiction-by-jurisdiction examination indicates that the compact growth alternative could have significant effect in reducing development of prime agricultural land in one-fifth of the jurisdictions, primarily those in Napa, Solano, and south Santa Clara Counties. In these 18 locales about 9,000 acres would not be needed for development, thus reducing the pressure

for conversion of prime agricultural land. In about one-third of the jurisdictions prime agricultural land is not a significant issue. In another one-third of the jurisdictions where about 11,000 acres would likely not be needed for development, prime agricultural land is of minor significance but does exist.

- Compact Growth Would
  <u>Reduce Damage to Vegetation</u>

Compact growth could play a significant part in reducing air pollution damage to plant species. Air pollution injury to vegetation has been observed for many years. Effects include leaf drop, reduced plant vigor, reduced plant growth, and death of plants. The most dramatic implications are to agricultural and other commercial crops. Some crops are no longer grown in the bay region because of air pollution. Others including grapes, carnations and orchids have been seriously damaged.

Within the region, ornamental growers have had to relocate to cleaner areas to avoid such damage. Annual damage in the bay region may be upwards of tens of millions of dollars.

Since the compact growth land use policies would be an important component of the package of actions to reduce hydrocarbon emissions, it can be expected that reduced vegetation damange due to air pollution will result.

- Compact Growth Would Reduce Conversion of
  <u>Mineral, Timber, and Geothermal Areas to Urban Uses</u>

The current development policies of local jurisdictions do not usually propose development of these extractive resource areas. However, the compact growth alternative could further reduce any potential for development that might affect the viability of such operations.

Extractive resources are significant in four highly urbanized areas: Richmond/San Pablo, Hayward and Fremont in the East Bay and Pacifica on the San Mateo coast. It is also significant in North Bay locations relatively remote from the pressures of regional urban growth: northern Sonoma and Napa Counties. In the two locations where compact growth would likely increase development pressure on these resources, Fremont and Hayward, both cities have special regulations protecting quarrying operations.

- Compact Growth Could Increase Development
  <u>Pressure on Public Development Sites</u>

The compact growth policies could increase pressure for private development of sites set aside for public projects such as airports, parks, community cultural and recreation centers, etc. It could also alter the type or intensity of development in the vicinity of such public projects from that which was the basis for design of the public facility. Compact growth may also increase competition for land in the vicinity, thus increasing the cost of the public project.

Airports could be impacted by having vacant land in the airport vicinity become more attractive for land uses not compatible with the airport. The compact growth alternative examined for the Air Quality Maintenance Plan does not propose increasing densities to the point of high-rise buildings near airports. However, the tendency of compact growth to encourage more population growth in bayside San Mateo and Alameda Counties can result not only in more people living and working near the airports, but in greater commercial growth to serve the added population. This type of commercial growth may compete for sites with airport-related industrial development that port facilities were designed to serve. Analysis of the compact growth projections indicate this could be a problem in the vicinities of San Jose and San Francisco airports. It does not appear to be a likely problem for the potential north bay regional airports at Hamilton in Marin, Travis in Solano and the Napa and Sonoma County airports.

Seaports could face the same problem with compact growth but not so consistently as with the airports. Only the Port of Oakland vicinity exhibits this trend in the compact growth projections. Locations near the ports of San Francisco, Richmond, Benicia and Redwood City could experience greater growth in basic employment with compact growth than they would with continuation of current local policy on development.

Compact growth could make land available in cities for recreational facilities more scarce, and probably more expensive than local jurisdictions have estimated in planning for such land acquisition. On the other hand, outlying land beyond currently proposed city services could prove cheaper to acquire for public use as a result of policies restricting its development. This, however, would not compensate for the fact that the compact growth pattern would inherently create a greater need for recreational land in the cities for use by the greater numbers of people who would live there. There might be a tendency on the part of local jurisdictions to forego the acquisition of in-city land in favor of cheaper land in the outskirts--land which might be suitable for non-urban recreation experience but inaccessible to low-income transit dependent city residents. State and Federal funding programs have placed emphasis on providing urban recreation facilities. The compact growth policies could have both positive and negative effects toward this emphasis. On one hand, more people would reside in cities and increased revenues might be available to finance recreational land acquisition. This might lead to increased use of, and improvement of existing facilities as well as demand for new ones. On the other hand, it may become more costly to acquire urban land for recreation. Unless these costs are overcome with State or Federal subsidies, in-city recreational opportunities might diminish somewhat.

III. IMPACTS ON ENERGY

The potential impact of the compact growth alternative on energy derives primarily from the same basis as its contribution to air quality: reduced auto use. Substantial reduction in gasoline consumption for automobiles would be only slightly offset by increased consumption of diesel fuel for buses. Compact growth could also result in notable savings in household energy consumption for heating, cooling, appliances, etc.

- Compact Growth Would Reduce Gasoline Consumption Due to Less Automobile Travel

Compact growth would likely result in a net reduction of almost 11 million vehicle miles of auto travel per year from the 95.6 million miles otherwise projected[1]. This reduction would result primarily from shortened commuter trips which in turn could result from:

-- Less distance between housing and jobs as both higher development densities and mixing of land use types reduces the need for auto travel; and

-- Improved transit service offering other home-to-work options for more workers, and also for other trip purposes.

It is estimated that the reduction in gasoline consumption would be 3.5 million barrels per year. This is the equivalent of somewhat more than 3 million barrels of crude oil per year. Translated into consumer terms this would be a savings of 147 million gallons of gasoline. This amount of gasoline would cost consumers almost $90 million a year (at 60¢ per gallon). This same amount of gasoline would enable all of the households in a city the size of Oakland to do their normal driving for one year.

- Compact Growth Would Increase Consumption of Transit-Related Fuel

Increased transit service would be a key transportation measure complementing compact growth. The recommended 20% improvement in transit service would constitute 571 additional buses running an estimated 17.9 million miles per year by 1985. The diesel fuel consumed in such additional bus service would be equivalent to 88 thousand barrels of crude oil per year, or 3,360,000 gallons of gasoline.

- Compact Growth Would Provide An Overall Reduction in Transportation Fuel Consumption

Net overall reductions in fuel consumption, reflecting both the reduced auto mileage and the increased bus mileage cited above would be equivalent to just under 3 million barrels of crude oil yearly. The significant effect of these fuel savings would not likely be felt until about

1985. The accumulated savings by the year 2000 would be approximately 45 million barrels of oil--15% of the petroleum output of California in 1975[2].

- Compact Growth Would Lower Per Unit Household Energy Consumption

It is generally recognized that factors other than residential density have the most significant effects on household energy consumption. However, if these other factors (i.e., such as wind and temperature variations, insulation, etc.) are assumed constant and density is examined as a significant variable, it is estimated that even moderately higher densities, as proposed in compact growth could notably reduce residential energy consumption due to more smaller units, common walls, etc. In the short term 10-year future when compact growth would encourage development of locations already proposed for higher density under current local regulation, savings would be modest--about 5%. In the longer term, beyond 1985, when compact growth would encourage densities somewhat higher than current local regulation but over widespread areas, the savings in consumption could range from 12% to more than 30%, depending on whether electricity or natural gas dominates in residential heating and cooling. The higher savings would ensue if natural gas continues to be the main source of fuel for residential heating.

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[1]See AQMP Technical Memorandum No. 22

[2]Source: State of California, Division of Oil and Gas, cited in Cry California, Summer 1977 annual review issue.

IV. IMPACTS ON AMENITIES

• Compact Growth Would Preserve Scenic Areas

The major effect of compact growth on regionwide scenic quality would be in the preservation of suburban and rural ridgelands and scenic valleys. Many communities in Marin, San Mateo, and the East Bay have already taken action to preserve suburban ridgelands as "community separators" so as to maintain individual community identity. The region-wide impact of compact growth would be the preservation of scenic routes, or "corridors", that traverse a number of jurisdictions. Many state and county designated scenic routes are dependent upon consistent multi-jurisdictional action to preserve their continuous unique character.

• Effects on Specific Scenic Areas

Local action consistent with the compact growth alternative would on one hand tend to discourage coastal area development well beyond the limited jurisdiction of the Coastal Commissions and on the other hand encourage high density development near the Bay but beyond the jurisdiction of BCDC.

Unique suburban valley communities such as those in Marin could experience lessened pressure for hillside and ridgetop development. Compact growth would also guide growth away from unique scenic rural valleys such as the Napa Valley, because it would support local efforts to contain urbanization to the close-in area of the valley cities.

Wildlife habitats and agricultural areas with unique scenic qualities such as Suisun Marsh in Solano, the rolling hills of West Marin and the agricultural area of East Contra Costa would experience lessened development pressures.

The urban and suburban ridgelands of the East Bay and South Bay where urban development pressures are imminent could be preserved by concerted multi-jurisdictional action as suggested in the regionwide Compact Growth alternative and similar to that already under way in Santa Clara County. In Alameda and Contra Costa Counties pressure to develop the ridgelands is apparent in the city or county development policies for Hayward, Moraga, and the unincorporated communities of Orinda and Castro Valley.

• Compact Growth Would Increase The Number Of People Exposed tp Urban Noise Levels

The compact growth policies, in assuming the trend of growth can be accommodated in a more compact, higher density pattern of urbanization, could result in increased exposure to noise due to two phenomena:

-- More people would be in closer proximity to existing and potential noise generators;

-- Construction noise will be more of a problem as localities experience more intensive building and rebuilding over a more constant period of time.

These noise problems would be most greatly felt in the older urbanized areas of Alameda, Santa Clara, and San Mateo Counties as these locations would experience a greater share of total regional housing growth (66%) than would be the case assuming current trends and current local policies region-wide (52%).

As the compact development policies are implemented, more new housing, hospitals, schools and other noise-sensitive land development would be built in closer proximity to sources of transportation noise: more congested highways, more active transit lines, and more active airports. Since homes would be closer to work, shopping, etc., more new housing would also be in closer proximity to shopping, business, and industrial district noise.

No detailed analysis has been done to identify the numbers of people within critical proximity of such noise generators as highways, shopping centers, industrial districts, etc. Limited analysis indicates that about 14,000 more people would be located near to the San Jose Airport and about 30,000 more people near to the San Francisco Airport by the year 2000. More efficient noise attenuation techniques would need to be an integral part of the design of all buildings, public facilities, vehicles, etc.

V. INSTITUTIONAL IMPACTS

Institutional impacts of compact growth relate more specifically to the land use management policies (Appendix C) recommended in the AQMP than do any other impacts assessed. Most would affect the everyday planning and zoning administration of cities and counties. Some would affect more directly the urban service responsibilities of cities and counties as well as special districts. Finally, the land use policies will affect intergovernmental coordination among State, regional, and local agencies.

This section of the report reviews the sixteen recommended land development policies (See Appendix C) as they relate to the various levels of governmental institutions. Status of various types of implementation programs are cited.[1]

- Greater Coordination Would Be Needed Among Local Agencies Whose Decisions Affect Development

Coordination among the service providing agencies, including both cities and special districts, is essential to accomplishing the basic objectives of Policies A, B, and C. These objectives are encouraging development where urban service capacity exists or is committed, and discouraging development beyond the reach of such urban services.

This would involve first the refinement of the way in which most Local Agency Formation Commissions (LAFCO's) carry out their mandate to define "spheres of influence" for all service-providing local agencies within each county, and for cities and special districts. Establishment of an "urban service area" concept in seven counties that encompass 76 cities may require additional staffing of the LAFCO function or reorganization of this function vis-a-vis the county planning agency.[2]

Early completion of needed sewer, water, or transportation service (Policy D) may require new arrangements for cities and counties, as general purpose units of government, to review the plans and capital improvement programs of single purpose special districts which provide these services within the city or county jurisdiction. Cities, counties or LAFCO's may require additional staff or reallocation of staff to accomplish such review functions. The special districts too may have problems providing needed information if their staff is limited. Approximately 43,000 acres of developable land, distributed throughout more than 70 cities in the eight counties of the region outside of San Francisco, is dependent upon early completion of these services.

Improving highways and transit consistent with when land development occurs (Policy E) may also require new arrangements among cities, counties, and large independent districts such as BART, AC Transit and the Golden Gate Bridge Highway and Transportation District, as well as county level or smaller transit districts.

Rebuilding in the inner cities (Policy F) and building to "infill" land bypassed by development (Policy G) may involve special services and facilities to overcome the unique problems that impede such development now. More than just inter-agency cooperation may be needed. Totally new commitments and changes in capital programs may be called for.

- Compact Growth Would Mean Significant Changes in Planning and Zoning Activities

Significant amendments to regional and local general plans, zoning ordinances, subdivision regulations, etc. would almost certainly be needed in many jurisdictions.

Encouraging development of land that has urban service capacity (Policy A and C) and restriction of development beyond the reach of such services (Policy B) may require rezoning, resubdivision or permit preference procedures as incentives to development in some locations, and as disincentives in other locations.

Already serviced lands constitute about 95,000 acres distributed through about 90 of the region's cities in the eight counties outside San Francisco, and including significant vacant acreage in San Francisco as well. This is roughly equivalent to the already developed area of Alameda County.

In the case of previously subdivided land beyond the reach of sewer or water service, compact growth may necessitate cooperative permit moratoria between counties and cities, or joint programs among cities, counties, and special districts to allocate or restrict sewer or water hook-ups. It is estimated that land in this development category approaches 14 thousand acres in the eight counties outside San Francisco.

Establishing some form of "staged zoning" or "sequence zoning" (Policy E) may require new ordinances in many of the region's actively growing cities. It is currently in effect, or expected by 1980, in eleven cities and two counties.

Rebuilding in the inner cities (Policy F) may require significantly revitalized or reorganized economic development, community development and redevelopment functions. Thirty-three of the region's 93 cities have active economic development programs involving redevelopment, special facilities commitments, and other incentives. Thirty-four cities have active housing conservation programs, involving systematic code enforcement programs, publicly assisted housing, etc.

"Infill" (Policy G) development of bypassed vacant parcels may require changes to planning research programs in most of the region's cities to collect information on the quantity and quality of such land and problems associated with incentives to its development. It is estimated that there may be as much as 40 thousand acres of such land in the urban areas of the region.

Higher development densities within urban service areas (Policy H) may require review and amendment of at least 50 and perhaps more of the zoning ordinances and/or general plans for the nine counties and 92 cities. Twenty-nine city and seven county jurisdictions have indicated they are, or recently were, in the process of mass rezoning to achieve plan conformance, and as many as 17 cities and seven counties may be actively "down-zoning" to lower densities.

Limiting low density development (Policy I) on land with soil, slope or other problems could require review of as many as 34 local planning programs to determine how these special problems are being handled.

Improving the balance of housing and jobs in major subareas of the region (Policy J) could involve review of 25 or more subregional areas involving from 3 to 12 jurisdictions each. Rezoning or inter-jurisditional fiscal and urban service arrangements could be needed to allow more housing opportunities closer to job opportunities.

Encouraging a greater mixture of residential/commercial/industrial land use (Policy K) would presumably involve review of all local zoning ordinances and general plans in the region to find formulas that are already workable in different types of jurisdictions. This would require reallocation of local agency staff to work in such a program.

- Implementing Compact Growth Would Require Increased Governmental Coordination and Technical Support.

Increased governmental coordination across city, county, regional and state structures would be essential to at least seven of the policy areas indicated in the compact growth alternative.

Early completion of needed sewer and water lines (Policy D) affects the needed development potential of approximately 43,000 acres within urban service areas, in the vicinity of more than 70 cities in eight counties. Committing needed State or Federal subsidies and local funding for these facilities to assure early completion would be essential to the objective of compact growth.

Rebuilding and conserving the housing supply (Policy F) in the cities will undoubtly require reallocation of agencies staff at all levels to deal with essential public sector committments of needed facilities, subsidies, etc. ABAG and appropriate State agencies would need to maintain or increase their technical staff capabilities and commitments to housing programs consistent with the level of effort already given to the environmental programs.

Achieving a better balance of housing and jobs (Policy J) in all subregions to reduce inter-jurisdictional commuting will require not only more housing expertise and technical service support to local agencies, but would also require staff and technical service expertise in new economic development programs. Regional and State agencies would need

to achieve a balance consistent with the level of effort given to the environmental programs. ABAG's Industrial Siting Project is a major step in this direction.

Funding facilities only after action consistent with the plan recommendations (Policy N) would have major inter-governmental impact. Single purpose agencies unaccustomed to having their recommendations weighed against other regionwide needs and dependent upon specific actions of other units of government will need to commit staff and officials to participation in unfamiliar but related programs. Technical advisory committees and inter-agency joint programs will require more attention and thus a larger portion of the typical agency's operating budget.

Discouraging large-scale single-use development projects (e.g.,"bedroom suburbs") as called for in Policy L and review of all major development projects for air quality effects (Policy N) would require new staff commitments on the part of regional agencies. Joint powers agreements, memoranda of understanding, joint staff work programs etc. would be required on the part of ABAG, the Metropolitan Transportation Commission, the Bay Area Air Pollution Control District, and the State Air Resources Board (ARB).

Local planning agencies would need to augment their own project review functions to assess non-air quality local impacts of the recommendations that emerge from such regional agency reviews.

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[1]Source: ABAG 1976 Local Development Block Survey (mailback questionnaire).

[2]The urban service area concept has been in effect in Santa Clara County since 1973. The function is jointly sfatted by the County Planning Department and the County Administrators office. San Francisco has no LAFCO.

VI. FINANCIAL IMPACTS

Financial, or fiscal, impacts of compact growth examined include the effects of greater use of capacity of existing urban services, capital construction costs; costs in collection of solid waste; impacts on the urban tax base, tax assessments, sales tax revenues; government administrative costs; and fees and user charges in outlying areas.

- Compact Growth Would Use Existing And Currently Planned Capacities In The Region's Sewerage Facilities, And May Result In Lower Taxes, User Charges, Etc.

Existing and currently planned expansions in the region's wastewater treatment facilities will provide a total treatment capacity of at least 690 million gallons per day by the year 2000. Assuming the low projection of regional growth (5.4 million population by the year 2000) and current local land development programs, about 630 mgd would be needed by the year 2000. Some of the need would be so located in suburban areas as to require plant expansions while bypassing already existing capacity in urban area systems. The compact growth alternative would require about 640 mgd of the planned 690 mgd capacity. Thus an additional 10 mgd of the existing or currently planned for capacity would be used under the compact growth alternative.

One fiscal effect of compact growth is the cost savings associated with the impacts on the region's treatment facility construction needs. Compact growth recommendations would direct development into currently urbanized portions of the region and away from areas which do not currently have urban services. The urbanized areas of the region, for the most part, have sufficient capacity in sewerage treatment facilities to accommodate development without plant expansions beyond those currently planned. As an example, the East Bay Municipal Utility District's facilities currently have a capacity of 120 mgd. The 80 mgd projected wastewater flow in the year 2000 under the compact growth alternative could be handled by the EBMUD system without any capacity expansion. Seven projects would be deleted from the 20 year treatment facility list as they would not be necessary under the compact growth alternative. Deletion of those projects would save approximately $60 million (expressed in 1977 dollars) in capital and operation and maintenance costs.

In the case of eight proposed treatment plant expansion projects, the effect of compact growth is to delay the need for expansion from one to seven years. For example:

> --The currently planned expansion of the Sonoma Valley County Sanitary District plant could be delayed for about 5 years. The estimated cost of the proposed plant expansion is approximately $5 million. The capital cost savings of deferred construction would be about $500,000 (in 1977 dollars) and $320,000 in operating and maintenance costs (in 1977 dollars).

--The currently planned expansion of the Petaluma sewerage treatment facility could be delayed up to seven years. The estimated cost of the proposed expansion is approximately $5 million. The capital cost savings of the deferred construction is $890,000 (in 1977 dollars)[1] and the operating and maintenance cost savings about $580,000 (in 1977 dollars).

It is easy to understand the savings in operating and maintenance costs because the delay in construction will obviate the need for plant maintenance. Capital cost savings are slightly more difficult to understand. The savings in capital costs are analogous to the savings in bank interest payments you don't have to make if you don't take out a loan. It may be argued that this savings will be eliminated by inflation in construction costs during the delay. However, all costs in the plan are expressed in terms of constant dollars. Constant dollar values include consideration for inflation because inflation affects equally the costs and the revenues of implementing agencies.

The other treatment facility expansions which could be delayed under the compact growth alternative are: Cities of San Mateo, Foster City, Rodeo, Pacifica, Pinole Sanitary District, Valley Community Services District, and Eastern Contra Costa County Sanitary District.

- Compact Growth Would Mean A Major Reduction Regionwide In Capital Construction Costs Due To Limited Extension Of Public Services

Savings due to compact growth would result from the need for fewer facilities such as utility lines and miles of public streets due to higher densities (less extensive development) and more contiguous development. It is estimated that regionwide a net savings of $81.5 million would result because fewer sewer and water lines would be required for residential development over the period 1977-2000; it is also estimated that regionwide a net savings of $68 million would result because fewer miles of local streets would be required.[1]

Although savings in operating and maintenance costs were not estimated for the above services, it is expected that such savings would result due to the fewer miles of street and sewer and water lines required for compact growth.

Savings from the provision of public services such as schools and libraries would also result because the demand for often underused existing facilities will increase, particularly in urban areas. Correspondingly, fewer new facilities would have to be constructed in suburban and rural areas.

The demand for fire and police services would be expected to remain roughly the same as under current programs. Potential efficiencies from fewer miles traveled for emergency and patrol vehicles would not be significant. However, some savings for fire protection may result from the rebuilding and renovation of older, more fire-prone areas.

- Compact Growth Could Result in More Efficient Solid Waste Collection And Lower Collection Costs

It is unlikely that the AQMP recommendations for compact higher density development would, in and of themselves, result in any significantly greater efficiencies in solid waste collection.

The recommended increase in densities are moderate on a locality by locality basis, seldom being more than 10% greater than would occur under current local programs. In no case would they result in a notably different housing type in any given locality (e.g. apartments instead of conventional single-family homes).[2] Furthermore, the areas most affected by the density increases would be new growth areas. By the year 2000 new growth areas would comprise about 29% of the total housing units served in either compact growth or the current programs alternative. In terms of land area to be served,in the year 2000, new growth areas would constitute about 52% of total residential land under current programs and 40% under compact growth. The remaining 60% of the total residential land in the year 2000 would be that area already developed where the changes would have little or no effect.

In any event, more efficient solid waste collection would not necessarily occur as a result of higher density development. Certain costs (overhead, etc.) would likely remain constant. If current collection practices are not efficient, moderately higher densities affecting only new growth areas will not significantly affect those inefficiencies in the already developed areas.

If current operations are efficient, and if moderately higher densities do improve operations somewhat, that component of increased efficiency will be small. It will again affect primarily the new growth areas and consequently be a relatively insignificant change in the total operations picture.

Thus lower solid waste collection costs are not likely to result from compact growth. Conversely there is no reason to conclude lesser efficiencies and higher costs as a result of compact growth either.

- Compact Growth Would Increase The Tax Base For Urban Areas

From the compact growth scenario, it is estimated that single-family construction within urban areas would increase 24 percent and multi-family construction would increase 45 percent over what would occur under current local programs during the period 1977-2000. This could result in an estimated residential assessed valuation increase of $6.6 billion (excluding land value changes) for this period based on the average housing market values reported in Section VIII of this report. This is an average of $2.9 million a year for urban area jurisdictions.

The increase in assessed valuation due to the development of retail trade and services within urban areas is estimated to be about $74 million over what would occur under current local programs in the 1977-2000 period. Assessed valuation was estimated to change relatively little for other types of development, including industrial.

- Compact Growth Could Cause Individual Property Tax Assessments To Increase, Then Level Off

Compact growth policies could affect the value of developable vacant land as well as already developed land in the vicinity of new building activity. Urban areas would be expected to experience greater increases than suburban areas.

Many market factors affect the assessed value of property and thus increases in assessed value. The estimated increase in market value which is assumed attributable to the compact development alternative ranges from 1% to 12% for four housing types: 1) elevator apartments; 2) walk-up apartments; 3) town houses; and, 4) single-family units. The ABAG Housing Profile Study reports an annual increase of 10% in average market value of owner-occupied residences in the Bay Area from 1970-75 due to inflation alone.[3]

The assessed value of properties would not automatically increase, thus resulting in an immediate increase in the tax bills. There is usually a two to four year lag between value changes and corresponding assessment changes so that the time effect is difficult to predict. The time lag may serve to spread the increase over several years. The assessed value of property in California should be 25% of the fair market value of the property. The fair market value estimates are based on the current market selling price of comparable properties. Inflation, rising property values and County Assessor's periodic (rather than annual) reassessment often results in an assess value of less than 25% of market value. (In 1975-76 the Statewide average was 24.7%).

- Compact Growth Could Cause Sales Tax Revenues To Increase In Urban Centers

As discussed in Section VII of this report, an increase in commercial development would be expected in urban areas due to compact growth. This would result in greater sales tax revenues for these areas under the assumption that the new residents would spend part of their disposable income in the urban areas that otherwise would have been spent in suburban and rural areas. The urban shopping districts and centers may also attract shoppers from outside the area, particularly those who work in the urban areas, but reside in the suburban or rural areas.

- Compact Growth Would Be Expected To Increase Government Administrative Costs

The costs of local government and regional agencies administering the compact growth alternative fall into three basic categories:

Local Cost For Planning and Zoning Administration

The two basic concepts to be carried out by local planning and zoning agencies would be the urban service area concept and the increase in allowable zoning densities. The zoning adjustments are assumed to be comparable to the general plan/zoning consistency programs carried out in all jurisdictions as a state mandate.

The urban service area concept, as carried out in Santa Clara County since 1973 has been estimated to cost a maximum of 39¢ per capita per year in one large jurisdiction, San Jose. This figure would probably be lower in large population counties and as high in the smaller population counties where essentially the same type of work would need to be done for each jurisdiction regardless of size.

Additional local costs to administer changes in zoning, and urban service area concepts of compact growth are estimated to range from $1.7 million to $3.0 million per year, regionwide.

<u>Local Costs for Relocation of Displaced Households</u>

The largest increase in government administration costs would probably be due to the relocation of households. It is difficult to estimate the number of households that would require relocation assistance. However, for Oakland, the average cost of relocating a residential tenant is $3,000, while a residential owner-occupant averages $13,000. Administrative costs average $550 per case. Non-residential relocation costs, such as a commercial or industrial occupant, vary too much to generalize.

Assuming from 3,000 to 6,500 cases per year (equivalent to the current attrition in housing units per year) the total costs for relocation could range from $10 million to $40 million per year.

<u>Regional Costs For Ongoing Regional Development Policy</u>

Assuming a continuing program comparable to ABAG's programs since 1973 would entail both staff costs and pass-thru funds to local lead agencies to conduct updating and monitoring of policy information and development trends.

Most of these costs have been borne by Federal grants and Federal support would be expected to continue. The estimate of ABAG costs is $200,000 per year. Estimated local agency costs to be borne by pass-thru grants to local jurisdictions are estimated at $300,000 per year. Total annual costs are estimated at $500,000.

- <u>Compact Growth Could Cause Fee And User Charges To Increase In Certain Outlying Areas</u>

Utilities (e.g. water and sewer lines) are often extended to subdivisions which develop beyond urban areas. Most interceptor sewers are designed for a projected twenty year capacity flow. Existing developments pay a fee for connection and sewer charges. As further development occurs the service charges generally decrease as additional connections and use of the capacity of the system occurs. Should the expected development in the area served not occur, the existing residents and commercial/industrial users would continue to pay the same or even higher user fees. In other words, sudden development restrictions designed to cut-off further development in such areas could increase the burden on early residents.

The compact growth alternative should not create such burdens. It does propose development restrictions in outlying areas, but only in areas lacking such service commitments. Compact growth is specifically intended to utilize the development potential not only in areas where services already exist, but also in areas where such services are now only committed in capital improvement programs. Such areas of committed services are very extensive in the region, comprising over 70,000 acres regionwide (roughly equivalent to the already developed area of Contra Costa County).

In cases where one essential service already exists or is committed but another service is lacking (e.g. water service but no sewer service) the compact growth alternative recommends accelerating the capital commitment of the second needed service. Such areas needing new commitments are also extensive, comprising about 11,000 acres regionwide (about equivalent to the already developed area of Napa County).

Footnotes:

1) Preliminary analysis by MTC indicates that less freeway and highway construction would be needed but no cost estimates are available.

2) See discussion in Section X.

3) ABAG, Housing Profile: 1970-75, San Francisco Bay Area, November 1977.

VII. IMPACT ON PRODUCTION OF GOODS AND SERVICES

The potential impact of the compact growth alternative on the production of goods and services would be most notable in terms of shifts of new economic activity from the outlying suburban areas back to the older urban areas of the region. Of secondary significance would be its potential effect on transit service and employment.

- Compact Growth Would Increase Job Opportunities in Urban Areas

The compact growth alternative would encourage more intensive commercial and industrial development in the older established business communities as indicated in Table VII-1. The approximately 7,000 more jobs in urban areas would be predominantly retail trade and retail service jobs located for the most part in the older urban areas of San Francisco, bayside San Mateo County, northern Alameda County, northern Santa Clara County, and central Contra Costa County--locations serviced by rail or express bus transit. The potential shift to urban areas would constitute slightly more than 1% of total job growth in the region over the period from 1975 to the year 2000.

TABLE VII-1

LOCATION OF NEW PERMANENT EMPLOYMENT
1975-2000
CURRENT PROGRAMS/COMPACT GROWTH
(x 1000 jobs)

Location	Current Programs	Compact Growth
Urban Areas	418.7	425.5
Suburban Areas	103.7	98.1
Rural Areas	12.7	11.5
Total	535.1	535.1

- Compact Growth Would Increase Commercial Activities in Urban Areas

The compact growth alternative would result in increased commercial activities in urban areas measured both in terms of increased commercial employment and in terms of new households locating in urban areas as indicated in Table VII-2. About 6,500 commercial jobs (2% of total regional commercial job growth) and over 110,000 households (16% of total regional growth in households) could be expected to locate in the urban areas rather than in outlying suburban or rural areas. The job location emphasis in urban centers would be most pronounced in the service categories, both retail services and business services.

TABLE VII-2

LOCATION OF NEW COMMERCIAL EMPLOYMENT AND NEW HOUSEHOLDS

1975-2000
CURRENT PROGRAMS/COMPACT GROWTH

	New Commercial Jobs (x 1,000 jobs)		New Households (x 1,000 households)	
Location	Current Programs	Compact Growth	Current Programs	Compact Growth
Urban Areas	288.0	294.5	301.4	412.1
Suburban Areas	48.4	43.1	387.8	288.9
Rural Areas	4.1	2.9	23.1	11.3
Total Region	340.5	340.5	712.3	712.3

- Compact Growth Would Mean Less Commercial Growth in Outlying Areas

As indicated in Table VII-2, about 6,500 fewer commercial jobs (constituting about 2% of total regional commerical growth) could be expected to locate in outlying suburban or rural areas with implementation of the compact growth alternative. With about 110,000 fewer households in such outlying areas (-27%) it is expected that those outlying commercial centers already well located with respect to transportation facilities, and offering a multitude of retail and service outlets could still expect growth oriented to widening market areas.

- Compact Growth Would Be Conducive To Increased Transit Service

Compact growth would require improved transit service in the urban areas. Conversely, it would itself be conducive to improved transit service because it would discourage auto use and encourage transit use. These effects would be most notable in existing rail transit corridors such as BART in the East Bay and Southern Pacific in San Mateo and Santa Clara Counties.

Higher density urban development acts both to restrain auto use and to encourage use of public transit. This is usually due to related aspects--larger or more intensive central business districts and higher density residential neighborhoods.

The compact growth alternative would maintain a residential density pattern more supportive to transit service than would likely result from a continuation of current zoning. Densities above 7 dwelling units is a generally accepted figure as the density threshold necessary to support significant transit use.[1)]

As indicated in Table VII-3 the regionwide average density in 1975 was 7 units per net acre but would decline below this threshold by the year 2000 due to typically low zoning densities, especially in suburban areas.[2)] Compact growth would maintain a density pattern near this regionwide density threshold while the development pattern under current programs would drop well below the threshold figure.

TABLE VII-3

REGIONWIDE RESIDENTIAL DENSITIES[a)]
CURRENT PROGRAMS/COMPACT GROWTH
(Dwelling Units/Net Acre)

	1975	2000	
		Current Programs	Compact Growth
Urban Areas	10.0	10.2	11.5
Suburban Areas	4.9	2.8	3.3
Total Region	8.0	5.4	6.7

a) Includes San Francisco.

The locations where the compact growth alternative would most encourage transit supportive densities include the San Rafael, Santa Rosa and Petaluma areas and the cities in the San Francisco bay plain including bayside San Mateo County, northwest Santa Clara County, and bayside Alameda County from Fremont to Albany.

- Compact Growth Would Increase Transit-Related Employment

The compact growth alternative would, as indicated above, be conducive to improved transit service. In the AQMP a 20% improvement in transit service is assumed by 1985. The additional 500 to 600 buses alone could mean at least 500 to 1,500 added jobs in the transit industry regionwide by 1985. No specific improvements in transit service levels were assumed in the AQMP beyond the 1985 figure. However, assuming the density increases proposed beyond 1985, additional transit service even beyond that proposed in the AQMP might well be feasible, resulting in an additional increment of jobs in the transit industry.

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1) Public Transportation and Land Use Policy, Boris S. Pushkarev and Jeffrey M. Zupan, Indiana University Press, 1977, p. 30.

2) Regionwide density figures are for eight counties outside San Francisco.

VIII. IMPACTS ON INCOME AND INVESTMENT

The assessment of impacts of compact growth on income and investment cover primarily potential shifts in the location of investment within the region. Also covered are notable effects on the housing industry due to encouragement of higher density residential production. Finally, effects on residential and industrial land prices are examined.

- Compact Growth Would Lower Regionwide Demand For Private Investment in Public Capital Projects

Although it can be anticipated that both the total level and the distribution of private investment in public capital projects would be affected, not enough information is available to estimate it quantitatively. The provision of public services and facilities will affect where people live and where jobs locate. Investment in retail trade and services will locate roughly in proportion to the development of housing and industry. Compact growth would accommodate the same amount of development regionwide as would be the case under the aggregated current local growth management programs.

As seen in Section VI of this report the need for certain public sewer projects could be delayed due to existing facilities excess capacity being able to fill the need. Also capital construction needs for highways, sewer collectors etc., would be reduced.

- Compact Growth Would Shift Emphasis of Public And Private Financial Investment From Outlying Areas To Urban Areas For Renovation and Replacement

The primary difference between the likely result of a continuation of existing local regulations and urban service programs on one hand, and compact growth on the other is the emphasis on the suburban to urban shift of new households. Under current local programs new construction in outlying suburban and rural areas would constitute almost 60% of all new residential building activities over the next 25 years. Under compact growth outlying locations would constitute about 42% of new residential building activity over the 25 year period, while new building on vacant land in the urban areas would constitute about 38% of total. Infill and rebuilding in the urban areas would constitute about 20% of total, supplemented by a needed heavy emphasis on renovation of the existing housing that is substandard.

- Compact Growth Would Stimulate Housing Rehabilitation and Maintenance Industries

Urban area rehabilitation is already increasing without the likely incentives of compact growth policies. Building permits for residential additions and alterations rose sharply from about 36,000 per year in the early 70's to over 51,000 in 1976. The average value per permit has gone up from $2,100 to almost $3,400, with total valuation in 1976 up to $171 million.

If the focus of housing demand does center on the existing urban areas, as per the objectives of the compact growth alternative, there may be a direct stimulus to rehabilitation. However, if the housing market also responds to the recommendation for more new multiple unit residential construction in the suburbs, and also notably for more small-lot lower cost single-family residential construction within the cities where there is plenty of room for it, the construction of new housing units might maintain an adequate supply of housing to meet the demand of growth in households. In this event the recent upward trend in rehabilitation might again turn downward.

- Compact Growth Would Stimulate
  Higher Density Housing Production

Demographic and economic trends are already stimulating higher density residential production. The inflationary cost increases to land, labor, and building materials are starting to put the traditional single-family home out of the reach of many middle-income families. Also, lower fertility rates are resulting in smaller households demanding more apartment units. The U.S. Census Bureau recently reported that many of these smaller households are obtaining housing in central, urbanized areas.

Compact growth may be far less significant as a causal factor in stimulating high density housing production than the above socio/economic factors. However, the compact growth alternative would encourage this shift toward townhouse and apartment construction especially in the longer term period from 1985 to 2000. Table VIII-1 below indicates that in the short term to 1985 it would encourage about 2,200 more townhouse and apartment units per year than would be the case with current local programs. In the longer term, when compact growth would encourage about 47% of all new units as higher density units, almost 4,000 more such units would be built per year than under current local programs.

This proportion of multi-family units to total is consistent with building permit activity over the last decade, when such permits constituted 47% of total. The historic pattern of development has been for single-family unit production levels to vary in greater frequency than multi-family, which tends to follow steep declines or increases of production. The nature of multi-family development requires a longer development period because of the difficulties of land acquisition, capital formation, design, processing, and general inertia for large-scale projects. Multi-family housing is also more likely to be affected by nationwide economic and investment trends.

TABLE VIII-1
HOUSING UNITS PER YEAR BY TYPE
RECENT HISTORY / CURRENT PROGRAM/ COMPACT GROWTH
(x 1,000 units)

Housing Type	1969-1976 BUILDING PERMIT RANGE[a] Low	High	1975-1985[b] CURRENT PROGRAMS	COMPACT GROWTH	1985-2000[b] CURRENT PROGRAMS	COMPACT GROWTH
Conventional Single Family	(1970) 18.5	(1971) 30.8	26.5	24.3	14.9	11.0
Clustered, Townhouse & Apartments	(1975) 6.7	(1971) 35.8	13.4	15.6	6.0	9.9
Total units	(1975) 25.9	(1971) 66.6	39.9	39.9	20.9	20.9

a) The lowest number of conventional single-family units were built in 1970. The lowest number of multi-family units were built in 1975 which was also the year of the lowest number of total units built. The year 1971 was the high year for all three categories.

b) Occupied housing units. Does not account for vacancy factors or the need to replace units lost due to demolition or natural causes.

The compact growth alternative would also encourage a shift in develement location from outlying suburban areas to more centralized urban areas. Over the 25 year period from 1975 to 2000, approximately 110,000 new housing units (15% of total new units) would likely be built in urban areas rather than suburban areas. Most (75%) of these new urban area housing units could still be built on extensive vacant acreage but such acreage is in smaller supply than in the suburban areas. A significant portion (20%) of these new urban housing units would involve either rebuilding of existing units or replacement of units lost to attrition.

The economics of such urban locations, whether vacant land or rebuilding, inevitably involve higher costs than the suburban counterpart. The economics of multi-family housing versus single-family suggest that relatively more of the new urban units would be multi-family.

To assess this, the impacts of demolition costs and land value increases were estimated for typical urban area residential densities.[1] The effect of demolition or extra site preparation costs of 27 percent of the land cost results in a market value increase of 7 percent for single-family units, 5 percent for townhouse units, 2 percent for walk-up apartments,

and about 1 percent for elevator apartments. Land costs represent about 27 percent of the total market value of single-family units, 18 percent for townhouses, 9 percent for walk-up apartments, and 2 percent for elevator apartments. These estimates suggest a move to higher density production in order to yield feasible per unit costs.

- Compact Growth May Affect The Housing Industry Profit/Cost Structure

As discussed above (and in more detail in Section X of this report) compact growth would result in a significant shift away from the building of conventional single-family housing, toward the building of higher-density single family units (townhouses, "zero-lot line", etc.) and apartments (both walk-up apartments and elevator apartments).

Table VIII-2 indicates the percentage proportions of conventional single family/clustered, townhouse and apartments that would be expected if compact growth were implemented. Also indicated are the proportions in selected recent years as indicated by building permit activity.

TABLE VIII-2
PROPORTION OF HOUSING BY TYPE
RECENT HISTORY / CURRENT PROGRAMS / COMPACT GROWTH

HOUSING TYPE	SELECTED YEARS BUILDING PERMITS DISTRIBUTION[c)]		1975-1985		1985-2000	
	1976[b)]	1970[c)]	CURRENT PROGRAMS	COMPACT GROWTH	CURRENT PROGRAMS	COMPACT GROWTH
Conventional Single Family	75%	38%	66%	61%	71%	53%
Townhouses or Clustered Units			12%	14%	19%	16%
Walk-up Apartments	25%	62%	11%	13%	9%	16%
Elevator Apartments			10%	12%	9%	15%
Total	100%	100%	100%	100%	100%	100%

a) Building permit data not available for breakdown of multi-family units.
b) Year between 1969 and 1976 with highest proportion conventional single-family units.
c) Year between 1969 and 1976 with lowest proportion conventional single-family units.
Source: California Construction Trends, Security Pacific National Bank.

The dynamics of the private market suggest that the housing industry may construct smaller single-family units on less land and relatively more apartments in response to compact growth if financing and other factors support it as in some recent years. This may result in a lower profit rate-of-return if the mark-up is less for multi-family versus single-family units. It is estimated that there is an average profit of 8 percent for multiple units versus 13 percent for single family custom homes.[1)]

Average market values were estimated per unit for the following four housing types within an urban area for 1977: single-family, $86,000; townhouse, $64,000; walk-up apartments, $43,000; and elevator apartments, $61,000.[2)] All three multi-family housing types are lower on a per unit basis than single-family. The elevator apartments become a more attractive option as land values increase within denser urban areas. In order to estimate the minimum incomes needed to purchase these types of units, a range of 30 to 35 percent of market value was used. This resulted in the following estimated income ranges for each housing type: single-family, $25,000 to $30,100; townhouse, $19,200 to $22,400; walk-up apartment, $12,900 to $15,050; and elevator apartment $19,200 to $21,350.

In 1977 dollars, the urban standard metropolitan statistical areas of San Francisco-Oakland and San Jose had median family incomes of $18,235 and $19,245, respectively. This indicates that over half the families in the region are in the under $19,000 bracket. This suggests that the walk-up apartment and elevator apartments may begin to look economically more attractive to more households in the market, especially the growing number of both young and old childless couples. The implications for investment and ownership in housing may not be as alarming as the first glance at the proportion of conventional single family versus other units indicates. The compact growth alternative is not overwhelmingly different in this regard than building activity in the last decade as indicated by building permits. It is also not greatly different, 5% in the aggregate, than current programs in the short term to about 1985. The major difference here lies in the longer term when, under current programs, single family units would dominate if current zoning and service commitments hold true. As indicated in other sections of this report and AQMP reports, higher density residential development in the long-term future is essential to the package of AQMP measures designed to maintain air quality after 1985.

The investment and profit motivation for multi-family housing is different from that of single-family housing. Since most single family housing is owner-occupied there is no expectation of positive cash flow. Price is therefore more heavily affected by mortgage capacity in the housing market, level of demand, and some attention to tax benefits. Multi-family housing, on the other hand is mostly renter-occupied. There is some expectation of positive cash flow on the part of investors and great attention is paid to tax considerations.

The emphasis on other than conventional single family units in the longer term future does not necessarily mean that individual home ownership will become less prevalent than now. Condominiums and co-ops may offset some of the tenure shift, but that may require more emphasis on high-rise apartment structures and large-scale townhouse development in both urban and suburban areas. Considerable emphasis on innovative small-lot single family houses may be essential. Revival of small-lot living may be as much a case of revitalizing older in-city housing as a case of new ideas for small-lot housing designs that fit today's construction techniques.

The potential impacts on the building industry of a lesser emphasis on conventional single family construction are perhaps less clear. In the past decade the industry has demonstrated the ability to vary the proportion of conventional single family units vs other units far beyond the potential difference between compact growth and current local programs. It may also reflect the relative independence of the single and multi-family housing market.

There may be different implications for small and large builders in the region. On one hand, an emphasis on large scale apartment construction in both urban and suburban areas may encourage entry of large-scale apartment builders from outside the region. On the other hand, an emphasis on small-scale but widespread renovation in the urban areas, plus an emphasis on scattered-site building ("in-fill" of scattered vacant sites) might benefit the smaller building firms in the region.

Whichever way the impacts may fall, implementation of compact growth would need two basic programs from both the public and private sectors:

-- A campaign to demonstrate to the buying and investing public the need/desirability of somewhat higher density living. (A return to patterns that were acceptable in the 1920's and 1930's.)

-- A campaign to build public facilities (sewer programs, etc.) that are needed to make higher densities possible; <u>and</u> a means to expedite the development permits so that building projects that support the objectives of compact growth can enjoy lower paper-work costs.

- <u>Compact Growth Could Cause Residential Land Prices To Increase In Urban Areas And Decline In Outlying Areas Beyond Urban Services</u>

Land prices are higher in areas where the intensity of use is higher. Residential land prices are generally lower on the urban periphery and increase toward the higher density urban centers. From data supplied by the Northern California Real Estate Research Council, the average increase in land prices from the urban periphery to the urban centers in the Bay Area is about 22 percent (excluding the very high density areas).

Compact growth will make certain areas more attractive than others, including areas already zoned for higher density development. This change in demand will affect land prices, but by how much is not clear. Various studies have estimated land price changes in similar programs from 25 to 50 percent.[3] The effect of these changes on urban area housing market values is estimated for four housing types, as indicated in Table VIII-3.

TABLE VIII-3
MARKET VALUE AND LAND VALUE
IN TYPICAL URBAN AREAS
ASSUMING COMPACT GROWTH

Housing Type	Estimated Percent Increase In Market Value	Land Value As Percent of Market Value
Conventional Single Family	7% to 8%	27%
Townhouse	4% to 6%	18%
Walk-up Apartment	2% to 3%	9%
Elevator Apartment	about 1%	2%

The effect of such land value changes are more significant for single-family and townhouse units because land represents a higher proportion of the total cost than for walk-up apartments and elevator apartments.

- Industrial Land Prices Would Not Be Significantly Impacted By Compact Growth

The industrial land assumptions in the compact growth alternative were virtually the same as those in the analysis of current local programs. Vacant land zoned for industrial use was assumed equally available for industrial development regardless of the status of service commitments. The compact growth alternative assumed programs would be developed to mitigate severe existing imbalances between jobs and housing in some urban areas.

The regionwide industrial land reserve and projected industrial land development are indicated in Table VIII-4. The industrial land reserve of over 62,000 acres is 12% greater than the amount of land currently in industrial use. Both alternatives could be expected to consume about 14,000 acres (22% of the reserve) leaving almost 49,000 acres in reserve in the year 2000.

The minimal difference in consumption of industrial land (about 300 acres more consumed in compact growth) would constitute an infinitesimal proportion of the reserve. Thus it is concluded that industrial land prices would not be affected by compact growth due to the large supply of land in the industrial reserve.

TABLE VIII-4
INDUSTRIAL LAND REGIONWIDE
EXISTING & POTENTIAL
(x 1,000 acres)

Industrial Land Use	1975	1975-2000[a)] CURRENT PROGRAMS	1975-2000[a)] COMPACT GROWTH	2000 CURRENT PROGRAMS	2000 COMPACT GROWTH
Acres in Use	55.2	+ 11.5	+ 11.8	66.7	67.0
Vacant Acres Zoned For Industrial Use	62.3	- 13.5	-13.8	48.8	48.5

a) Difference between new industrial land in use and consumption of vacant land zoned for industry is land consumed for streets (about 15%).

Source: ABAG 1976 Local Development Policy Survey and ABAG Series 3 Projections (Base Case 2).

1. Lee Saylor, Inc., Current Construction Costs 1977, Walnut Creek, California.

2. Lee Saylor, Inc., Housing Cost, EMTF Special Study Prepared For Association of Bay Area Governments, January 5, 1978.

3. Massell, Benton, The Urban Development/Open Space Program in Santa Clara County, Stanford University, September, 1973; and Urban Land Institute and Gruen, Gruen and Associates, Effects of Regulation on Housing Costs: Two Case Studies, ULI Research Report #27, The Urban Institute, Washington, D.C., 1977.

IX. IMPACTS ON CONSUMER EXPENDITURES

The assessment of potential impacts of compact growth on consumer expenditures includes the examination of such items as: housing production lags causing increased housing prices; waste collection charges; property taxes; energy charges; disposable income; and consumer housing perference both in terms of housing type and location (urban, surburban, and outside the region).

- Compact Growth Could Increase Housing Prices and Rents Due to Production Lags As Builders Adjust To Zoning and Subdivision Regulation Changes

Compact growth could result in a lag in housing production if the recommendations are sporadically applied. For example, constraining growth at the suburban fringe without increasing opportunities in urban areas could cut into the supply of land needed for housing. However, continuation of current zoning practices and deferred commitments to provide needed sewer and water service could also cause a lag in production. In this current situation where the supply of land for higher density housing is rapidly depleting, the building industry would be seeking case-by-case zoning changes for higher density building more frequently than in the last decade. Thus, a consistent regionwide program is needed.

In discussion later in this report on effects of compact growth on new residential building (Section X) it is indicated that both in terms of future housing type and location, compact growth would not differ greatly from building industry practice in recent years. Since 1969 the building industry has been able to pick and choose locations zoned for higher density building for up to half of the units built in any given year. Similarly, the industry has been able to pick and choose urban locations for about two-thirds of the units built. But those sites will grow scarcer unless current local programs encourage higher density building on close-in sites. If local jurisdictions do so in a consistent regionwide pattern the building industry should have less of an adjustment problem than it does now with regulations that differ widely across the region.

As indicated in the previous section of this report, housing prices would increase somewhat as a result of the compact growth shift of some new housing development from suburban to urban areas. It is estimated that the typical new conventional single-family unit built in the urban area rather than suburban would see about a 7% increase in market price. Townhouses would increase about 4% in market price while apartments would increase by 2% or less due to the urban location.[1] The higher density units, which could experience the lesser price increase as a result of compact growth would constitute an ever larger proportion of total units built.

- Compact Growth Could Reduce Upward Trend in <u>Residential Waste Collection Charges</u>

It is unlikely that the recommendations for compact development would in and of themselves reduce the trend of increasing residential waste charges. As indicated in the discussion of solid waste collection in Section VI of this report, the moderately higher densities recommended in compact growth would not likely result in notably greater efficiencies in collection, or in notably reduced collection costs.

Even if such efficiencies and incremental "savings" in operating costs were to be realized by the operator due to compact growth and somewhat higher densities, it is unlikely that such savings would be passed onto the consumer. It is more likely that such savings in operations would merely be used to offset other increased costs of operation (labor, equipment, fuel, etc.).

- Compact Growth May Cause Increases in Urban Area Property Tax Revenues to Support Services to New <u>Development and Because of Increased Land Values</u>

Under the compact growth alternative, the construction of new single-family units would increase 24 percent within urban areas for the period 1975-2000; and the construction of multiple-family units would increase 45 percent. Using estimated market values (including land) for these units and a range of 1976 Bay Area property tax assessment rates of $9.3 to 13.2 per $100 of assessed value, the increase in property tax revenues over the period 1975-2000 for new residential construction in urban areas is estimated to be $614 to $870 million in current (1977) dollars.[2] This would be an annual average of $28 to 39.5 million dollars.

If the urban area land values were to increase by an average of 25 percent,[3] the estimated additional property tax revenues for the new residential construction alone would increase by approximately four percent. This would range from $24.6 to 34.8 million dollars for the 1975-2000 period, or an average of $1.1 to 1.5 million per year.

Increased property tax revenues from retail trade, retail services, and other local-serving establishments would increase within urban areas for the period 1975-2000. Property tax revenues from a typical community shopping center, with annual taxable sales of $13.5 million dollars, is estimated to range from $83,000 to $120,000 per year.

The shift of additional industrial employment to urban areas under compact growth was estimated to be relatively small. Therefore, any increase in property tax revenues from industrial development as a result of compact growth is expected to be insignificant.

The effect of such new urban area construction on the assessed land value of existing homes in the already built-up area is estimated to be about 4% for a 25% increase in land values. Inflation rates alone averaged 10% per year from 1970-75 for owner occupied housing.

- <u>Compact Growth Could Reduce Upward Trend in Residential and Commercial Energy Charges</u>

In the section of this report dealing with energy consumption (Section III) it was concluded that *if* factors other than residential density are assumed constant, that a compact growth development pattern could notably reduce overall residential energy consumption. However, to make the further step of estimating the cost effect on a typical housing unit goes beyond available information.

Since the potential efficiencies and savings would primarily affect the new higher density units, no more than 29% of total housing units by the year 2000 would experience these efficiencies. Even assuming the efficiencies are realized by this proportion of consumers it is questionable whether any cost savings would be passed on to the consumer through variable rates. They might more likely be absorbed by the utilities as trade-offs for other rising costs of overall operation such as labor, equipment, etc.

- <u>Compact Growth Could Mean More Disposable Income Due to Lower Transportation Costs</u>

The shortened commuting patterns of compact growth could result in a decrease in aggregate commuting costs across the region of about 11% compared with current programs.[4] In another section of this report it was noted that the gasoline savings could be as much as $90 million per year regionwide.

This potential decrease in commuting costs could permit increases in expenditures for other consumption items. Such savings in transportation costs might be traded off with housing costs.[5] Payment, whether in purchase or rental, for higher cost housing can translate into higher land values which in turn enhance the property tax base.

- <u>Compact Growth May Shift Housing Demand Outside the Bay Area</u>

Compact growth is not intended to slow or stop housing demand in the region. It is intended to accommodate the same amount of housing demand regionwide as would be the case with the aggregate of current local growth programs. Any unintended shift in housing demand would result secondarily from other effects on price, available choice in housing type, or available choice in housing location.

Assuming however, that the aggregate of these other effects still does have some potential impact, however small, on the choice of living inside the region or outside the region, it is useful to get a sense of who such

potential migrants are and how large a component of housing demand they may constitute. Four types of potential out-of-the-region migrants can be identified:

1) Those who shift to jobs outside and then shift to housing outside the region. For this group there would have to be more jobs outside the region than within the region in order for their component of housing demand to be drawn outside the region.

2) Those who shift to housing outside and then may seek jobs outside the region. For this group the attractiveness of the whole housing package: price, convenience, and amenities is presumably considered. The total attractiveness of the housing package outside the region, including job shift if long distance commuting costs and inconvenience are considered, has to be considerable to exceed the comparable package within the region.

3) Those who simultaneously shift to jobs and housing outside the region. For this group the choice is probably made independent of factors that might keep their housing demand within the region.

4) Those already situated within the region who may consider a housing shift outside the region. For this group the shift in demand must involve a housing package (as in 2 above) that clearly exceeds the comparable package within the region. And, costs and inconveninece of long distance commuting to work in the region will weigh more heavily if transportation costs continue to spiral.

The historical experience of a continuing net in-migration to the region suggests that either on the basis of job opportunity or on the basis of net attractiveness of housing and other amenities, there is and will continue to be a housing demand within the region. All things considered, the minimal effects of compact growth are not likely to overcome these trends. Indeed, if compact growth contributes to maintaining the environmental quality and other amenities of the Bay region it may contribute to maintaining the region's housing demand.[6]

- Compact Growth May Affect Consumer Housing Preference

Consumer housing preference is largely a product of the householders' needs and/or desires tempered by ability to pay. It is usually expressed in the type of housing chosen and its location.

A household's housing preference usually changes over time as a function of the household's lifecycle, as indicated below. Household income, of course, intrudes across any pattern of preference as indicated in the following chart.

The demographic and location trends as to household size are reflected in the same way in the household estimates for both the current local programs and policies and the compact growth alternative. Average household size regionwide is expected to decline from a 1975 figure of 2.65 persons per household to 2.30 persons per household by 1985 and further to 2.10 persons per household by the year 2000. This is assuming the lower fertility rates of the 5.4 million population level by the year 2000.

Stage of Household	Estimate of Duration	TYPICAL HOUSING PREFERENCE TYPE	LOCATION
1) Individual establishes household	5 years	Apartment	Urban: job opportunities cultural and recreational amenities; other singles.
2) Family formation	5 years	Apartment or small house	Urban: same as above; or couples.
3) Arrival of children	5 years	Larger house	Urban or suburban; other families; homogeneous socioeconomic environment.
4) Educational needs of children	20 years	Larger house	Urban or suburban: quality schools; homogeneous socioeconomic environment.
5) Departure of children	5 years	Small house or apartment	Urban or suburban: cultural and recreational amenities; other couples.
6) Death of one parent	10 years	Small house or apartment	Urban: Convenience of cultural and health facilities and shopping, etc. Rural: Environmental Amenities and Seclusion

Both alternatives considered here, compact growth and current local programs, are assumed to have the same pattern of distribution of household types: the urban areas dominated by (but not exclusively) smaller households in the early and late stages of the household lifecycle; and, the suburban areas dominated by (but not exclusively) the larger households with children.[7]

The estimated potential for housing by type relative to the number and size of projected households is tempered in the current programs alternative by zoning densities now in force in local jurisdictions; and in the compact growth alternative by assumed density increases in those locations where sewer and water service is available and where transit service is also available. Any shift in the estimated number of housing units by type would,

for the most part, be due to the assumed density increases. Any shift in the estimated number of units by location would be due to the assumptions of more developable land in the urban areas (infill, rebuilding and earlier commitments to needed sewer and water service) and less developable land in the suburbs (e.g. less spetic tank development and less steep slope development which necessitates low densities).

The potential new housing choices, in terms of housing type and location for both compact growth and the current programs alternative, are estimated in Table IX-1 below.

Under current programs about 69% of the units that could be built would be conventional large-lot single family structures (51% suburban single-family); about 11% would be townhouses or other small-lot housing complexes, while about 20% would be apartments. Under compact growth there would be about a 12% shift away from the conventional single-family units. About 57% of the units that could be built would be large-lot single-family homes (with suburban single-family constituting about 35% of total).

TABLE IX-1

POTENTIAL CHOICE OF NEW HOUSING
CURRENT PROGRAMS/COMPACT GROWTH
1975-2000
(x 1000 housing units)

Housing Type	CURRENT PROGRAMS Urban	Suburban & Rural	Total	COMPACT GROWTH Urban	Suburban & Rural	Total
Conventional Single-Family	125.0	363.6	488.6	155.2	252.7	407.9
Townhouses or Clustered	61.2	20.8	82.0	88.8	19.9	108.7
Apartments	115.2	26.5	141.7	168.2	27.5	195.7
TOTAL	301.4	410.9	712.3	412.2	200.1	712.3

Source: ABAG Base Case 2 and Compact Growth 2 Projections

a) Occupied housing units. Does not account for vacancy factors or the need to replace units lost due to demolition or natural causes.

It is estimated that 3 or more person households presently constitute about 42% of total households and that with declining family sizes, by the year 2000 they will constitute only about 27% of total. Assuming these households would prefer conventional single-family housing, new housing under compact growth would probably meet that need in <u>total</u> (57% of total units) <u>but</u> not necessarily in suburban locations. Housing

built consistent with current low-density zoning regionwide would likely far surpass any need of large households for large housing units on large lots.

Small households are estimated to be an increasing proportion of total (more singles, childless couples--especially the elderly). They presently constitute about 58% of total and are expected to increase to about 73% of all households by the year 2000. Under current zoning and commitments for sewer service, etc. about 31% of new units built could be smaller-lot homes or apartments. Under compact growth about 42% of new units built could be smaller-lot homes or apartments.

Assuming that trends toward smaller households means preference for apartments and smaller homes it appears that compact growth would come closer to such a preference than would current local zoning and service programs, but it too might fall short of the long-term need to allow more apartment and townhouse building in both urban and suburban areas.

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[1]Lee Saylor, Inc., Housing Cost, EMTF Special Study Prepared for Association of Bay Area Governments, January 5, 1978.

[2]A range of property tax assessment rates were chosen from the Bay Area's "urban" counties (San Mateo, San Francisco, Santa Clara, Alameda, and Contra Costa). The highest rate in 1976 for urban counties was $13.20 for Alameda, while the lowest rate was $9.30 for San Mateo. Source: State Board of Equalization, Annual Report, 1975-76.

[3]Urban area land values were estimated to increase 25% in urban San Jose as a result of implementation of the countywide Urban Development/Open Space Plan in 1973, a plan similar in concept to the AQMP compact growth alternative. Source: Massell, Benton, The Urban Development/Open Space Program in Santa Clara County, Stanford University, Steptember, 1973.

[4]See discussion of reduction in vehicle miles of travel, Section XI.

[5]See discussion of reduction in gasoline consumption, Section III.

[6]Compact Growth has been determined to be a significant component in the Air Quality Maintenance Plan's potential for reducing air pollution. See discussion in the AQMP report. Also see disucssion of compact growth impacts on other environmental concerns elsewhere in this report. (Sections I throug IV).

[7]Also see the Housing Supply (Section X) discussion of the needs of large families and large households of unrelated individuals for large homes.

X. IMPACTS ON THE SUPPLY OF HOUSING

The compact growth alternative could have significant effect on housing in the region. One most notable and intended effect would be on the location of new housing sites--less in outlying suburban areas, more close to and within the older cities of the region. Another intended effect, more higher density housing types than current zoning would allow, is essential to the objective of reducing distances between housing, work, shopping, etc., and encouraging use of transit. Other possible effects, such as encouraging conversion of older single-family homes in the cities, could result. All effects examined could be expected to be moderate in the years to 1985 and more pronounced from 1985 to the year 2000.

It is essential to set the context for comparing the compact growth alternative to what would be likely to happen to the new housing supply with current regional trends and current local programs, especially zoning and sewer and water service.

Location of Sites For New Housing

In the short-term future to 1985 compact growth assumes less development of outlying sites where current regulations do allow low density development. Lack of sewer service or other conditions (such as steep hillsides) necessitate very low density development in these locations -- frequently less than one dwelling unit per acre. Secondly, compact growth assumes more development of in-city sites already zoned by local jurisdications for cluster development, townhouses, or apartments, and already served by sewers, water, road systems, etc.

In total, compact growth would offer 21% more housing sites over the 25 year period, due primarily to higher densities after 1985. If the compact growth recommendations are carried out, a shift in emphasis from sites in outlying suburban and rural areas to urban areas could be expected as indicated in Table X-1. About 200,000 more housing sites would be available in urban areas than under current programs while about 29,000 fewer sites would be available in outlying suburban and rural areas. About 130,000 of the potential urban area sites would result from rebuilding and infill of previously bypassed parcels. The remaining 392,000 potential urban area sites would involve extensive acreage that has existing or committed urban services.

Table X-1

LOCATION OF NEW HOUSING SITES[a)]
1975-2000
CURRENT PROGRAMS/COMPACT GROWTH
(X 1,000)

Location of New Housing Sites	Current Programs	Compact Growth
Urban Areas	319.7	522.6
Suburban and Rural Areas	505.9	476.7
REGION	825.6	999.3

a) A "site" is the equivalent land area that can accommodate one housing unit under either existing or proposed zoning. See Appendix B

Table X-2

LOCATION OF NEW HOUSEHOLDS
CURRENT PROGRAMS/COMPACT GROWTH
(X 1,000)

Location of New Households[a)]	1975-1985		1985-2000	
	Current Programs	Compact Growth	Current Programs	Compact Growth
Urban Areas	178.8	219.0	122.6	193.1
Suburban Areas	215.1	176.5	172.7	112.4
Rural Areas	5.1	3.5	18.0	7.8
REGION[b)]	399.0	399.0	313.3	313.3

a) See Appendix A for definition of subareas

b) Occupied housing units. Does not account for vacancy factors or the need to replace units lost due to demolition or natural causes.

New Households Needing Housing

As previously indicated, about 712,000 new households regionwide would need to be accommodated in new housing units on these sites over the 25 year period to the year 2000. At the expected growth rate that would reach a population level of 5.4 million by 2000, land sites and housing would need to accommodate about 399,000 new households by 1985 and an additional 313,000 new households from 1985 to 2000. It is estimated that these households would locate as indicated in Table X-2. The anticipated shift to urban areas under compact growth can be seen to consist of about 40,000 households in the short-term to 1985 (10% of total new households) and about 70,000 in the long-term future from 1985 to 2000 (about 22% of total new households).

Housing Type

The estimates of new housing, by type, to accommodate this growth in households in indicated in Table X-3:

Table X-3

ESTIMATED HOUSING BY TYPE
TO ACCOMMODATE ADDED HOUSEHOLDS
CURRENT PROGRAMS / COMPACT GROWTH
(X 1,000 units)

Housing Type	1975-1985		1985-2000	
	Current Programs	Compact Growth	Current Programs	Compact Growth
Conventional Single-Family	265.0	242.9	223.7	165.0
Townhouses or Clustered Units	49.8	56.7	32.2	52.0
Walk-Up Apartments	43.7	51.2	29.2	49.2
Elevator Apartments	40.6	48.2	28.1	47.1
TOTAL HOUSING UNITS	399.0	399.0	313.3	313.3

[a] Occupied housing units. Does not account for vacancy factors or the need to replace units lost due to demolition or natural causes.

In the short-term future to 1985 about 22 thousand fewer conventional single-family units (18% fewer) and about 6 to 7 thousand each more townhouses, walk-up apartment units, and elevator apartment units could be expected.

In the longer-term period beyond 1985 the compact growth alternative assumes added service commitments and somewhat higher density zoning regionwide. This would result in about three-fourths (75%) the number of conventional single-family units, and about two-thirds again (167%) as many new townhouses and apartments as would likely occur under current programs.

The way in which the compact growth alternative would seek to accomplish these shifts--gradual in the short-term future and more pronouned beyond 1985--is essential to identifying potential impacts, both good and bad. The following discussions examine these impacts on the housing supply in more specific terms: where they would be felt and how they might effect specific aspects of the existing housing supply.[2)]

- Compact Growth Would Reduce New Residential Construction in Outlying Areas

The essense of the compact growth alternative in the near-term future is to reduce the proportion of new low-density residential construction in outlying areas. It is this typically low density housing pattern, built in suburban and rural areas beyond urban services and long distances from work and other opportunities (shopping, school, etc.), that has been the most significant contributor to the air quality problem. By restricting development at the extreme periphery, while encouraging it in areas that already have urban services, local jurisdictions can do much to alleviate the air quality problem with a minimal effect on the potential housing supply.

As was indicated in the Introduction (Table 2) compact growth assumes 43,000 fewer acreas would be developable than under current local programs. This is 13% less acreage overall. While about 62,000 fewer acres would be available in suburban and rural areas--land with development problems (lack of service commitments, steep slopes, etc.)--about 19,000 more acres would be available in urban areas than under current programs.

The location of potential housing sites is indicated in Table X-4. Given such a new distribution of housing sites made available for development by local jurisdictions, it is anticipated that new housing would tend toward the more urban locations as already indicated in Table X-2.

Table X-4

DISTRIBUTION OF NEW HOUSING SITES
1975-2000
CURRENT PROGRAMS / COMPACT GROWTH
(X 1,000)

Location of New Housing Sites	Current Programs	Compact Growth
Urban Areas	39%	52%
Suburban and Rural Areas	61%	48%
REGION	100%	100%

In the near-term future prior to 1985 it is likely that about 40,000 more units (10% of the total new supply) would be built in the existing urban areas of the region. Approximately 176,000 units (44% of total) would still likely be built in suburban locations, but in areas where local jurisdictions have already committed essential services and have already zoned vacant land for more city-like densities. Of prime importance is the fact that most of these suburban areas already have some transit service. More than 200,000 new units (about 55% of total) would locate in the urban areas.

In the longer-term future beyond 1985, the urban area emphasis of compact growth would be more pronounced, with almost two-thirds of the new housing units being located in the higher density urban areas where transit would be an available option for both commuting and for non-work trips. For this period between 1985 and 2000, 112,000 units, or about one-third of the new housing opportunities, would still locate in the suburban areas, but at higher densities than would be the case under current programs. Under current regulations and trends almost two-thirds of the new units built after 1985 (approximately 190,000 units) would locate in more sprawling suburban and rural locations.

- Compact Growth Would Increase New Housing Construction and Rehabilitation Throughout Urban Areas

Virtually all existing urban areas would experience more new housing construction if the compact growth recommendations are carried out. Rehabilitation of the older existing housing supply in the urban areas would be essential to compact growth. A revival of urban housing construction could occur as the result of the cities of the region encouraging "in-fill" development of scattered bypassed parcels within their built-up areas, as well as encouraging rebuilding in older areas.

New Housing in Urban Areas

As indicated in Table X-5, compact growth in the near-term future to 1985 would depend on almost one-half of all new units being built in the contiguous built-up area of the San Francisco Bay plain extending from San Francisco south to San Jose and north to Richmond. The major cities of the north bay would need to accommodate about 10% of all new units.

In the longer-term future from 1985 to 2000 the compact growth alternative would focus a larger share (over 50%) of new building in the Bay plain near to high capacity transit service and jobs.

Table X-5

HOUSING TO ACCOMMODATE ADDED HOUSEHOLDS IN URBAN AREAS OF THE REGION[a)]
CURRENT PROGRAMS / COMPACT GROWTH
(X 1,000 units)

Subregional Urban Areas	1975-1985 Current Programs	1975-1985 Compact Growth	1985-2000 Current Programs	1985-2000 Compact Growth
Major North Bay Cities[b)]	26.8	36.0	36.5	25.1
Cities in the East/West/South Bay Plain	152.0	183.0	86.1	168.0
TOTAL[c)]	178.8	219.0	122.6	193.1

[a)] In those locations that have fringe or suburban growth potential this information pertains to the older contiguous built-up areas.

[b)] San Rafael, Novato, Petaluma, Santa Rosa, Napa, Vallejo, Fairfield, and cities in Central Contra Costa urban subregion.

[c)] Occupied housing units. Does not account for vacancy factors or the need to replace units lost due to demolition or natural causes.

Rehabilitation in Urban Areas

Local jurisdictions estimate that there are currently 137,000 housing units in the region in substandard physical condition; of these about 101,000 units are estimated to be suitable for rehabilitation.[3] If current trends persist, by 1985 more than 206,000 units will be substandard, with 156,000 suitable for rehabilitation. For the compact growth alternative to approach its objective of more households locating in urban areas, it would be essential to rehabilitate more than 19,000 substandard units each year until about 1985. Expanded housing conservation programs and code enforcement programs would be needed to assure that currently standard units do not deteriorate, especially after 1985 when new building activity in urban areas should be accelerating.

The sooner that impediments to higher density housing construction in urban areas can be removed, the more likely compact growth can contribute to cleaner air. This would not mean high-rise housing in all city neighborhoods. It would mean preservation of the existing relatively high density housing supply in the cities, and rebuilding consistent with existing on-the-ground densities. Widespread "down-zoning" to densities lower than the existing on-ground densities in city neighborhoods would run counter to the objectives of compact growth.[4]

- Compact Growth Could Cause a Temporary Lag in New Building as the Building Industry Adjusts to New Development Practices and Building Types.

Overemphasis on building types and locations different from current building industry experience could cause a lag in needed housing construction as the industry adjusts to new practices. The compact growth alternative emphasizes only moderate shifts in the short term future to 1985 and more pronounced shifts from 1985 to 2000, but still within industry experience to date.

New Residential Building Types

As indicated in Table X-6, recent year-to-year shifts in residential construction suggest that building industry response to other factors, such as financing, already range further than the recommendations for air quality would differ from current programs. The range in building permits for apartment units and other non-conventional single family units has been from less than 7,000 units per year (1975) to almost 36,000 higher density units per year (1971). Current zoning together with servcie commitments would accommodate about 13,000 higher density units per year in the short term and about 6,000 per year in the longer-term period. Compact growth would accommodate from 10,000 to 16,000 higher density units per year. Such units would be about 39% of total units in the short term for compact growth, increasing to about 47% of total units in the longer term future. Since 1969 such higher density units ranged from 62% of total units (in 1970) to 25% (in 1976), according to permits issued regionwide.

Table X-6

NEW HOUSING UNITS PER YEAR BY TYPE
RECENT HISTORY / CURRENT PROGRAMS / COMPACT GROWTH
(X 1,000 units)

Housing Type	1969-1976 Building Permit Range[a] Low	1969-1976 Building Permit Range[a] High	1975-1985 Current Programs	1975-1985 Compact Growth	1985-2000 Current Programs	1985-2000 Compact Growth
Conventional Single-Family	(1970) 18.5	(1971) 30.8	26.5	24.3	14.9	11.0
Clustered, Townhouse & Apartments	(1975) 6.7	(1971) 35.8	13.4	15.6	6.0	9.9
Total units	(1975) 25.9	(1971) 66.6	39.9[b)]	39.9[b)]	20.9[b)]	20.9[b)]

[a)] The lowest number of conventional single-family units were built in 1970. The lowest number of multi-family units were built in 1975, which was also the year the lowest number of total units were built. The year 1971 was the high year for all three categories.

Source: California Construction Trends, Security Pacific National Bank.

[b)] Occupied housing units. Does not account for vacancy factors or the need to replace units lost due to demolition or natural causes.

Different Residential Building Locations

Compact growth recommendations for more emphasis on building in urban areas rather than suburban or rural areas could affect building industry practices keyed to large-scale tract housing developments of recent decades.

It should be emphasized here that the urban locations emphasized in the compact growth alternative do include extensive vacant acreage, as well as opportunities for so-called "in-fill" development on scattered vacant sites and potential for rebuilding. Up to three-fourths of the new housing opportunities in urban areas would still be potentially built on extensive vacant acreage. The difference between these sites and their suburban counterparts would be the fact that the urban sites would be those with existing or committed urban services.

It is estimated that in the short term future to 1985 up to 16,000 new units per year would be built on such extensive urban area building sites. Approximately 1,000 to 2,000 units per year would constitute rebuilding in the urban areas. Such rebuilding would involve public or private clearance of substandard or obsolete residential, commercial, and industrial uses. Approximately 1,000 units per year would need to be built on smaller scattered vacant sites previously bypassed by the building industry. About 2,000 to 3,000 units per year could be accommodated on vacant sites now zoned for commercial or industrial use where such sites have not proven attractive to non-residential development.

In the longer term beyond 1985 up to 10,000 units per year would likely be built on extensive vacant acreage in urban areas. About 1,500 units per year would involve rebuilding of older housing and commercial uses in urban areas.

As seen in Table X-7 building industry practice in recent years has emphasized building in such urban locations, but more so in the multi-family building boom of the earlier 1970s. About 47,000 units were built in the urban centers of the region in 1971. In the low building year of 1975, when single-family units dominated the building scene, the approximately 16,000 units built in the urban areas constituted almost two-thirds of all units built. The compact growth alternative, with its emphasis on encouraging local jurisdictions to "open-up" higher density building opportunities in urban areas, would enable the building industry to continue its historical practice of picking and choosing urban sites. Current local zoning regulations and service commitments if not changed would eventually force the industry into a suburban building mode with more than half the opportunities being in suburban locations. While such suburban sites might have the advantages of large sites, they would also be more likely to have problems of lack of sewer or water service, steep or unstable slopes, etc.

Table X-7

HOUSING UNITS PER YEAR BY LOCATION
RECENT HISTORY / CURRENT PROGRAMS / COMPACT GROWTH
(X 1,000 units)

Housing Location	1969-1976 Building Permit Range [a] Low	1969-1976 Building Permit Range [a] High	1975-1985 Current Programs	1975-1985 Compact Growth	1985-2000 Current Programs	1985-2000 Compact Growth
Urban Centers	(1975) 16.2	(1971) 47.0	17.9	21.9[b]	8.2	12.9[b]
Suburban and Rural Areas	(1975) 9.7	(1971) 19.6	22.0	18.0	12.7	8.0
REGION	(1975) 25.9	(1971) 66.6	39.9[c]	39.9[c]	20.9[c]	20.9[c]

a) Source: California Construction Trends, Security Pacific National Bank.

b) Includes building on scattered vacant sites (15%) and rebuilding (10%) as well as building on extensive vacant acreage (75%).

c) Occupied housing units. Does not account for vacancy factors or the need to replace units lost due to demolition or natural causes.

- Compact Growth Could Result in a Lower Proportion of Substandard Housing Units

Rebuilding of large numbers of substandard units would be essential to the success of any attempt at a more compact higher density land development pattern in the Bay Region. From 120,000 to 180,000 units would need to be rebuilt over the full 25-year period from 1975 to 2000 to accommodate households now living in urban areas. This would be on the order of 5,000 to almost 7,000 units per year.

The "normal" rate of attrition in the existing Bay region housing supply--natural destruction or demolition for conversion to new housing or other urban use -- has approached 6,500 units/year in recent years. The current 137,000 substandard units in the housing supply would have to be replaced or rehabilitated at the rate of over 5,000 units a year to totally eliminate substandard conditions. To eliminate substandard conditions and replace housing lost to attrition, an annual rebuilding rate approaching 14,000 units per year would be needed.[5]

Unless an unsympathetic public attitude toward public sector "urban redevelopment" of recent decades can be reversed, such a rebuilding effort would be largely up to the private sector housing industry. Obviously substantial incentives would be necessary to accomplish this.

One theory holds that compact growth would contribute to such inner-city revitalization by virtue of suburban building disincentives encouraging "reverse migration" back to the inner-cities. If so, housing quality might improve but not necessarily to the benefit of the lower-income residents living in these areas now.

Another theory is that increased demand in inner city areas will generate further deterioration as landlords and owner-sellers have less competition from suburban building and thus less incentive to maintain their properties.

Finally since historical increases and declines in housing quality have occured without consious attemts at compact growth policies it can be argued that such increases or decline may continue regardless of growth strategies.

- Compact Growth Could Increase Conversion of Older Single-Family Structures.

Older single-family structures represent a unique housing resource in the region. Their architectural value has been a major aspect in neighborhood preservation programs. More importantly in terms of housing supply, the larger structures represent a dwindling resource important to two special population groups:

-- large low-income families who need or desire to live in the cities convenient to transit and other essential services;

-- groups of non-related people who choose to share large quarters for economic or other reasons.

If the low growth population projection occurs, the number of 6+ person family households (a subjectively chosen figure for defining need for 4+ bedroom units) is expected to decline from 125,000 in 1970 to 95,000 in the year 2000. In this event the need for large units might decline, and a loss of up to 30,000 of the existing 195,000 large units could be tolerated without major negative effect on large-family

No information is available to quantitatively assess the relatively new demand for large houses by groups of non-related individuals. However, it is well known to be the only housing solution for large numbers of young single adults in their school and early working years. Doubling-up or housesharing is also a growing prospect for older childless couples and single people, especially tnose on fixed incomes.

FOOTNOTES

[1]For a definition of areas considered urban, suburban or rural see Appendix A.

[2]Potential economic impacts such as land price and housing costs are examined in Sections VIII and IX of this report.

[3]Source: 1977-78 Housing Assistance plans, Bay region cities and counties.

[4]In some jurisdictions existing "in-town" zoning allows densities far higher than exists on the ground in older neighborhoods. Downzoning such areas to preserve existing on-the-ground density patterns would not likely run counter to the objective of Compact Growth.

[5]Assumes potential double-counting of units both substandard and lost to normal attrition is off-set by number of substandard units rehabilitated rather than rebuilt.

XI. IMPACTS ON PHYSICAL MOBILITY

Compact growth on physical mobility can be expected to decrease auto travel mobility and increase non-auto travel.

- Compact Growth Would Reduce Regionwide Vehicle Miles of Travel

Travel analysis documented in Table XI-1 indicates that by the year 2000 the compact growth development pattern recommended would reduce total vehicle miles of travel (VMT) in the region by more than 10 million VMT. This would be a reduction of 11% compared to that expected under current programs. Vehicle miles of travel would still be significantly greater than the 1975 level (about 32% greater). Vehicle trips, as indicated in Table XI-2, would not be reduced as significantly--slightly more than 2%.

This indicates that compact growth's effect on auto mobility would be primarily in terms of the length of trips, not so much in reducing trip-making altogether. The most significant reduction in both trips likely to be made and their length would be in the category of work trips.

TABLE XI-1
VEHICLE MILES OF TRAVEL[a)]
CURRENT PROGRAMS/COMPACT GROWTH
(VMT x 1,000,000)

TYPE OF TRIP	1975	2000 CURRENT PROGRAMS	2000 COMPACT GROWTH
Work	20.8	26.5	23.5
Non-work	43.8	69.1	61.7
All trips	64.5	95.6	85.2

a) Total VMT, Interzonal and intrazonal
b) Source: AQMP Tech Memo 22, MTC, November 1977
c) Totals may not add due to rounding

TABLE XI-2
VEHICLE TRIPS[a)]
CURRENT PROGRAMS/COMPACT GROWTH
(Vehicle trips x 1,000,000)

		2000	
TYPE OF TRIP	1975	CURRENT PROGRAMS	COMPACT GROWTH
Work	2.1	2.6	2.5
Non-work	6.9	8.9	8.8
All trips	9.0	11.5	11.2

a) Total trips, Interzonal and intrazonal
b) Source: AQMP Tech Memo 22, MTC, November 1977
c) Totals may not add due to rounding

A greater potential for work trips being made by transit appears likely than for other trips, such as for shopping, recreation, etc.

- Compact Growth Would Mean Shorter Trips Resulting in Travel Time Savings

No travel time data is available to assess specific potential for time saving in the shorter trips indicated in Table XI-1. However, some conclusion can be reached from general information on potential congestion. The compact growth development pattern would be implemented in combination with improved transit service and increased transit use. As a result, highways would be less congested than would be the case assuming current programs. Assuming that less congestion means less time for any given trips, some savings in travel time would be accrued in most areas. However, there would be some potential for added congestion in a few local areas where travel time would be increased.

- Compact Growth Could Increase Local Traffic Congestion

Projection data for localities throughout the region were examined to identify those where compact growth could result in greater commercial/industrial activity, more housing growth, or both. Such indicators were assumed to represent potential for more trips into and out of the locality as well as within the locality. The following is a review of potential local areas of congestion. It should be emphasized that congestion would occur only if people in these localities cannot or will not use an alternate mode of transportation--transit, walking or bicycling.

In Marin County, Sausalito and downtown San Rafael could be affected due in both cases to expected increases in housing concentrations close to already active commercial areas.

In Sonoma County, Petaluma could expect more commercial activity and less housing as a result of compact growth. Increases in commercial based trips from outlying areas to downtown Petaluma could cause some local traffic congestion.

In Napa County there appeared to be no significant differences with regard to potential local traffic congestion.

In Solano County there could be some potential for increased congestion in Vallejo due to greater concentration of housing close to the already active commercial areas.

In Contra Costa County compact growth inducement of residential growth near BART could result in local traffic congestion in Lafayette, Walnut Creek, Concord and Pleasant Hill in the more urban part of central county; and also in the El Cerrito/San Pablo/Richmond locales of west county.

In Alameda County, the situation is similar to BART centered Contra Costa. Albany, Berkeley, Emeryville and north Oakland would likely experience more local traffic congestion due to residential growth encouraged near BART and near established job centers. In some locales in Oakland, Alameda, and San Leandro increased commercial activity resulting from Compact Growth might be as significant as increased residential growth in causing some increase in local traffic congestion. In south county locations the hill neighborhoods would likely experience less congestion while the central business districts of Hayward and Fremont would likely experience some increase in congestion due to both increased commercial activity and the BART transit focus.

In Santa Clara County the job center and rail transit focus of the northwest cities could result in more congestion due to both increased residential growth and increased commercial activity in compact growth. The more suburban communities of south and southwest county as well as Milpitas and east San Jose would likely experience less local traffic congestion than under current programs.

In San Mateo County, the less job intensive south bayshore communities would probably experience less traffic congestion with somewhat less housing growth under compact growth. The more job intensive and transit oriented localities in Burlingame, Millbrae, and Daly City would probably experience slightly more congestion.

In San Francisco no significant difference in congestion measures is evident between the compact growth alternative and that of current local programs.

- Compact Growth Would Result in Inconvenience For Private Auto Use

Compact growth with its companion transportation measures is intended to make private auto use less convenient--in those locations where other choices of transportation mode are aveilable. Secondly it is intended to reduce the number of people living and working in locations where transit and walking or bicycling to work, to shop, to school, etc., are just infeasible. In the case of transit, infeasible because of poor service or no service. In the case of walking or bicycling, infeasible because of the distances involved. In such locations cutting back on auto use would be much more than an inconvenience.

In the older, higher density cities compact growth would tend to cause traffic congestion, as indicated above, if people cannot or will not ride the bus, walk, or bicycle to their destination. Some period of congestion and inconvenience may result in more people choosing the non-auto mode where the auto is not really necessary, only somewhat more convenient.

- Compact Growth Could Increase Transit Availability For All Trip Purposes

Compact growth in and of itself would increase transit availability only by virtue of more people living and working near transit service. That is, bringing the people to transit, not bringing transit to the people. The compact growth alternative would result in about 200,000 more people living near transit service by the year 2000.

The transit service addressed here is the rail service of BART in the East Bay, San Francisco and northern San Mateo County, and Southern Pacific service in San Mateo, San Francisco and Santa Clara Counties. It also accounts for local and/or express bus service areas of AC Transit in the East Bay, San Francisco MUNI, San Mateo's SAMTRANS, and the Golden Gate system in Marin, Sonoma and San Francisco. Most of this transit service is oriented to commuter service, i.e., work trips, not other trip purposes such as shopping. Thus, the compact growth alternative cannot be said to increase transit availability for non-work trip purposes.

The compact growth alternative can achieve higher urban densities in more areas of the region, it may be that such an urban pattern could better support improved transit service in the off-peak hours for non-work trips. Such improved service would have to be both more frequent service but also more service coverage to more special sites such as hospitals, shopping centers, cultural centers, schools, etc. As indicated elsewhere in this report, (Section VIII) a relatively small increase in density in some localities could reach a level where use of transit, if service is provided, would be significantly higher. That positive effect on potential transit use together with the above indicated negative effect on auto use could contribute to that critical

balance of transit service and transit use that would indeed make transit service available for all trip purposes. But such an improved situation could not be expected until well after 1985 when both the transit service improvements and the recommended increases in development density could be expected to have effect.

- Compact Growth Could Improve Potential For Walking Trips As Urban Activities Are Brought Closer Together

The compact growth alternative in encouraging the mixture of residential, commercial, and some industrial uses, is intended to improve the opportunities to walk instead of ride between home, work, shopping, recreation, etc.

The only way compact growth can measurably affect such land use mixtures as the means to achieve this objective is by encouraging more people and more activities to locate in already mixed-use urban areas. Areas presently suburban in character--more or less exclusively low-density residential uses separated from low-density auto-oriented exclusively commercial and industrial areas--are not likely to be significantly changed in this regard by the amount of growth likely in such areas, no matter how dense or mixed it may be.

As indicated in Table XI-3, by the year 2000 about 200 thousand more people (1/3 of total added population in the region) would probably be located in such areas where walking might be a real option, than would be the case under current programs. The implications are that more people would be living in urban areas where walking is already an option. Suburban neighborhoods would not become that much more diverse or dense, and would not offer significantly greater opportunities to walk rather than ride.

TABLE XI-3
LOCATION OF JOBS AND PEOPLE
YEAR 2000
CURRENT PROGRAMS/COMPACT GROWTH

	TOTAL JOBS (x 1,000)		TOTAL POPULATION (x 1,000)	
LOCATION	CURRENT PROGRAMS	COMPACT GROWTH	CURRENT PROGRAMS	COMPACT GROWTH
Urban Centers	2,097.1	2,104.5	3,441.0	3,660.5
Suburban & Rural Areas	477.4	470.0	1,977.4	1,757.9
Total Region	2,574.5	2,574.5	5,418.4	5,418.4

XII. IMPACTS ON HEALTH AND SAFETY

The most critical aspect of compact growth affecting health would be its effect on the overall amount, and regionwide concentrations of photochemical oxidants and carbon monoxide. The most notable with respect to safety would be pedestrian safety in more concentrated development.

Photochemical oxidants have been found to cause irritation to the eyes, nasal passages, mucous membranes, respiratory system, and heart functions. Some of these effects have been observed at relatively low oxidant levels. Federal standards for oxidant levels have been set to protect sensitive population groups--including everyone at one time or another--children, the elderly, and the chronically or temporarily ill. High levels of oxidant occur periodically now in the Bay Region--two to three times the Federally mandated .08 ppm standard. The standard is exceeded more than 40 days a year at present. Automobile use is a major source of hydrocarbon emissions. These emissions contribute to oxidant formation.

- <u>Compact Growth Would Significantly Improve Public Health Due to Reduced Oxidant Concentrations Regionwide</u>

The air quality maintenance plan emphasizes control of vehicle emissions that contribute to photochemical oxidant. The compact growth alternative, as tested, could reduce hydrocarbon emissions by 24 tons per day and oxides of nitrogen by 26 tons per day. Inasmuch as compact growth, together with other AQMP measures, is designed to collectively reduce oxidants, comprehensive implementation should contribute to improved public health.

- <u>Compact Growth May Cause Greater Exposure to Localized Concentrations of Carbon Monoxide</u>

Regionwide, the AQMP compact growth alternative could contribute to reducing carbon monoxide--in the magnitude of 450 tons/day. However, if all the recommended AQMP measures are not implemented comprehensively, greater localized concentrations of carbon monoxide could occur. Those measures designed to reduce auto use, such as improved transit service, are essential. Otherwise, compact growth could result in more concentrated auto use--and carbon monoxide--in some high density locations. Carbon monoxide controls would be addressed in the continuing planning process recommended by the AQMP.

- <u>Compact Growth Could Increase Pedestrian Safety Problems on Local Streets</u>

A development pattern that encourages higher densities without curbing auto use could result in more pedestrians being exposed to more traffic on local streets. However, this would not be a problem with the compact growth alternative as tested for the AQMP because the plan:

-- Does not encourage extremely high densities. Densities proposed are higher than currently allowed under local regulation, but lower than densities that already exist, on the ground, in most local areas.

-- It is part of a comprehensive package of controls, including automobile disincentives and transit improvements, which should reduce auto use.

XIII. IMPACTS ON THE SENSE OF COMMUNITY

The most pronounced impact of compact growth on the sense of community would be its effect on neighborhood identity, although even this impact is not expected to be significant. Much less identifiable would be its potential social effects and its effect in making more time available for non-commute activities.

- Compact Growth Would Alter Neighborhood Identity Due To Greater Diversity and Density

A compact growth development pattern would tend to alter homogenous neighborhoods more than would be likely to occur under current local programs. In both urban centers and suburban areas, it would encourage a greater mixture of residential, commercial and office uses as well as a greater mixture of housing type. The degree of change in residential density and redistribution of commercail activity in the recommended development pattern is so slight that significant alteration of neighborhood identity is unlikely. However, the mixture of residential and neighborhood-scale commercial and office uses can add diversity and vitality to urban neighborhoods and strengthen the sense of community among those who live and work there. The supermarket in suburbia and the corner grocery or drugstore in densely populated urban areas often serve as community centers.

The degree of density increases assumed in compact growth were such that in no locality would the result be a notably different housing type than already allowed under local zoning. Thus in areas presently restricted to conventional single family homes (generally less than 5 dwelling units per net acre) the assumed density increase would at most allow densities compatible with clustered single family structures on small lots with common open space, or so-called townhouses (attached single-family units). Similarly, in locations where walk-up apartments (generally 3 stories, 5 to 19 units) are allowed under present regulation, the compact growth alternative would at most encourage low-rise elevator apartments (generally up to six stories, and 50 units, perhaps in combination with ground floor commercial or office uses). Compact growth would not encourage high-rise apartment towers in locations where such high densities (generally over 100 units/acre, and over 12 stories) are not already allowed by local zoning.

As seen in Section VII the redistribution of commercial activity under compact growth actually examined here is so minimal--6,500 commercial jobs scattered over 300 to 400 urban neighborhoods--that significant impacts altering the identity of any individual neighborhood is unlikely. If the commercial activity is of appropriate scale it can reinforce neighborhood identity.

- <u>Adverse Social Effects May Result From Higher Density Development</u>

Adverse social effects have been associated with certain conditions of overcrowding but not with high residential density per se. Again, the degree of density increase assumed in the compact growth alternative was not significantly higher in this regard than already allowed under local zoning. High-rise apartment towers would specifically not be encouraged where not already allowed under local zoning.

- <u>Compact Growth Would Increase Personal Time For Non-work Activity Due To Shorter Commutes</u>

It has been established elsewhere in this paper that compact growth would have a significant effect in reducing vehicle miles of travel, particularly for work trips (commuting). No information is available to establish that commute <u>travel time</u> would necessarily be reduced. It is likely that compact growth would result in shorter trips on more congested routes (in the higher density development areas) at slower speeds with travel time not necessarily reduced to any significant degree. Any significant time savings would accrue to the relatively few commuters who would likely not be driving extremely long commute distances from remote suburban or rural living locations to urban job centers.

XIV. EQUITY OF IMPACTS

Potential inequities of various impacts of compact growth have been cited as part of the examination of other issues. In this section four specific equity issues are examined: displacement of poor people and minorities, potential cost of living increases in urban areas, broadened middle to low income housing opportunities, and transit availability for transit-dependent residents. Before examining those specific issues, it is important to review the context of the broader problem.

The focus of the equity analysis is generally on the question who benefits ans who pays? The answers to those questions are not easy due to the complexities of the interactions between social, economic, financial, institutional, and environmental factors. For example, in some cases, there may be a very direct cause-effect relationship between a given recommendation and the impacts of that recommendation on special population groups such as minorities and low-income people. A classic example of a direct cause-effect relationship would be a situation where construction of a major capital facility would require the demolition of housing occupied by such special population groups. The impacts of that type of action could be considered either adverser or beneficial. The sense of community and the historic patterns of interaction and social movement that would be altered by rapid change of a neighborhood or destruction of the neighborhood would probably be viewed as a negative impact. On the other hand, if the residents are relocated to better quality housing and the new housing is physically grouped (thus reconstituting the neighborhood in a different location), the impacts could be considered beneficial or at least not significantly adverse.

However, what is more often the case is a situation where a recommendation does not have a direct cause-effect relationship, and thus the equity effects are more difficult to predict with certainty. Throughout the history of environmental control programs, there is the frequent contention that they adversely effect minorities and low-income groups. The contention often occurs because of the financing mechanisms used to implement a pollution control program or project. Where the costs to implement are financed entirely, or in part, through a regressive financing mechanism such as property taxes, ultimately the indirect impact of the recommendation will adversely effect low-income groups. A conclusive impact requires a detailed analysis on a case-by-case basis for each recommendation as the alternative methods of implementation and financing are identified. That level of detail is beyond the scope of this initial phase of the EMP. It is recognized as an important factor for the continuing environmental management planning process at both the regional and local level as local governments carry out the plan.

This section of the compact growth assessment attempts to describe several equity effects of compact growth relative to the effects of the continuation

Table XIV-1
SAN FRANCISCO BAY REGION

POPULATION (1970) (PERCENTAGES)

County	Minority Group						Total Population
	Spanish Heritage	Blacks	Chinese	Japanese	Filipino	Total	
Alameda	18.5	14.7	1.8	1.0	.9	36.8	100.0
Contra Costa	14.1	7.3	.6	.7	.5	23.2	100.0
Marin	8.7	2.4	.5	.6	.2	12.4	100.0
Napa	9.7	.6	.4	.3	.2	11.2	100.0
San Francisco	23.7	13.4	8.3	1.8	3.5	50.7	100.0
San Mateo	17.2	4.6	.9	1.0	1.1	24.8	100.0
Santa Clara	25.1	1.7	.8	1.5	.7	29.8	100.0
Solano	16.3	9.9	.5	.6	2.0	29.3	100.0
Sonoma	10.9	1.0	.2	.4	.2	12.7	100.0
Total For Region	19.1	7.9	2.1	1.1	1.2	31.4	100.0

TABLE XIV-2
POPULATION AND INCOME CHARACTERISTICS

	% Black	% Spanish Language/ Surname	% Other Non-Caucasians	% Elderly (65 or over)	Median Family Income ($)				% Families Earning Less Than $10,000	% Families Receiving Public Assistance or Welfare
					Overall	Black	Spanish Language/ Surname	Other Non-Caucasians		
Alameda	15.0	12.6	4.9	9.2	$11,133	7,850	10,208	10,432	42.3	5.2
Contra Costa	7.4	9.3	2.3	6.9	12,423	8,405	10,642	11,984	34.2	4.6
Marin	2.4	5.8	1.8	7.4	13,934	8,085	11,867	12,171	28.8	2.0
Napa	0.6	7.5	1.4	13.4	10,736	11,454	8,307	10,461	44.8	3.7
San Francisco	13.4	14.2	14.9	13.9	10,502	7,675	9,497	9,984	47.1	5.3
San Mateo	4.7	11.3	3.8	7.7	13,222	9,028	11,830	12,492	29.5	2.7
Santa Clara	1.7	17.5	3.7	6.0	12,455	10,674	10,026	12,574	34.2	3.9
Solano	9.8	10.8	4.3	6.7	9,880	7,761	8,680	9,084	50.8	4.2
Sonoma	1.0	7.4	2.0	12.9	9,672	5,795	8,032	8,685	52.2	4.9
Bay Area	7.9	12.8	5.4	8.8	11,745				38.7	4.3

Source: 1970 Census

of current local programs now in force. It is by no means exhaustive and in general is limited to a qualitative discussion of the potential equity impacts. In addition, many of the impacts of compact growth recommendations described in other sections of this assessment have or could have equity impacts, herein defined as impacts on special population groups e.g. minorities, youth and low and fixed income groups (including the elderly and the handicapped). The reader is referred, for example, to the sections that discuss employment impacts (Section VII), housing impacts (Section X) and health impacts (Section XII).

The Bay area enjoys a rich multi-cultural heritage. (Table XIV-1 shows the minority group percentages for the region. Table XIV-2 shows population and income characteristics.) By choice, or by discrimination, minorities have long been concentrated in a few locations in the nine counties of the region. Data from the 1970 census and a statistical analytic technique that defines and identifies sociological and economic patterns, relationships and associations provides information about the Bay Area's minority populations. In general, concentrations of minorities and low-income individuals occur in the older cities of the region. Blacks and Hispanics constitute the largest portion of the region's minority population and the largest number at or below the poverty level. Areas with a high percentage of the population that is Black, a high percentage of the population with incomes below the poverty level and primarily employed in services include the corridor from Richmond to West Oakland, South Oakland and the Hunters Point area. Other areas include Antioch-Pittsburg, San Jose, East Palo Alto and Marin City. The Spanish surname (Hispanic) subpopulation is concentrated in areas such as the Mission District, sections of Oakland, Hayward, Union City and other portions of southern Alameda County and the San Jose area. Poverty is also associated with these areas and these groups. Concentrations of the elderly subpopulation (older than 65) occur in much of San Francisco, northern portions of Berkeley and East Oakland as well as in central areas of Santa Rosa, Napa and Vallejo.

Significant air pollution problems exist in the region and particularly in many of the region's older, highly urbanized cities. Because those areas have substantial concentrations of minorities and the elderly and low-income individuals, those groups tend to be proportionately more exposed to the high concentrations of air pollutants which occur in those areas and thus to the deleterious health effects associated with air pollution. As air quality improves there should also be reduced exposure for special population groups, and thus fewer incidences of helath problems associated with air pollution. As part of the comprehensive strategy, compact growth would contribute to reductions in hydrocarbon levels, generally as a result of changes in travel patterns and modes. However, compact growth would probably not, in and of itself, significantly effect the situation in a direct way.

No significant changes in industrial development would occur under compact growth, so no reduction in the location of industry in urban areas is anticipated. The effect on hydrocarbon levels from industries in urban areas would be a function of the stationary source controls (including New Source Review) and not of compact growth. Compact growth would affect housing and

commercial development associated with housing, by directing this type of development into already urbanized areas with urban service capacities (or commitments for urban services). Because these types of developments are generally traffic generators, localized increases in concentrations of carbon monoxide could be expected to occur (see Section XII). As a result, the residents in areas experiencing such development would be exposed to higher levels of that type of pollution and the health related effects of the pollutant. The mobile source and transit controls should offset or mitigate many of the potentially adverse effects. The indirect source review would be another mitigating factor as would carbon monoxide controls recommended in the AQMP continuing planning process.

- Rehabilitation and Rebuilding of Substandard Housing Would Displace Poor, Aged, Minority and Handicapped Residents

Displacement of the poor, elderly, and handicapped occurs both directly, in the form of redevelopment projects and indirectly, through increases in housing price/rent and costs of consumer goods and services. Compact growth is likely to accelerate both forms of displacement beyond the rate that would occur under current programs, which would continue trends of more development in outlying areas. This is in part because compact growth calls for public and private re-investment in urbanized areas. Current local programs, on the other hand, tend to channel more investment into suburban and outlying areas that generally lack significant concentrations of the poor, aged and handicapped.

The compact growth alternative would not be workable without substantial rehabilitation and rebuilding of substandard housing, and building of new low-income housing, throughout the urban and suburban areas of the region.

The Section X discussion of impacts on the housing supply indicated that rehabilitation of over 19,000 substandard units each year to 1985 would be essential to achieving the objective of locating more households in the urban areas near jobs, shopping, transit, etc. That same discussion suggested that an estimated 6,500 housing units per year are lost to unplanned attrition and would need to be rebuilt to accommodate displaced households. It is not known exactly how many of the units lost each year are included in the information on substandard units. Therefore, approximately 20,000 units per year could be estimated as necessary to be either rehabilitated or rebuilt. Either action would imply at least temporary dislocation of a large number of residents.

The impact of such, at least temporary, dislocation would occur in the urban areas where the minorities, poor, aged, and handicapped are concentrated. For example, more than 50% of the region's Black and Hispanic minority populations are located in 18 of the region's largest cities, all situated in the older urban complex along the bay plain South of San Francisco and Richmond.

Assuming that the people potentially dislocated are residents of currently substandard housing or housing removed for other uses, and further assuming that they are already in need of housing assistance, the level of housing assistance needed to make compact growth dislocations equitable would be at least those already called for in local housing assistance plans. The level of housing assistance required could be even higher. The number of households now receiving such assistance is about 62,000 (3% of total). The average number of additional households per year that would need assistance would be at least 67,000.

Although relocation payments are available to residents displaced by public redevelopment projects, greater commitments are necessary, especially to counter the often insidious effects of private housing rehabilitation and renovation. The Federal government should assume greater responsibility for mitigating the relocation and other adverse impacts groups such as the poor, the

aged, and the handicapped of public redevelopment to achieve compact growth. The Federal air quality standards were set to counteract air pollution resulting from the sprawl fostered by Federal housing and transportation policies in the 1950s and '60s. Rent escalator clauses and deferred property tax assessments for elderly homeowners as well as rent rebates are examples of techniques deserving more widespread utilization. In the absence of these efforts, compact growth may serve to shunt the poor, aged and handicapped from one low income neighborhood to another, while benefiting higher income resettlers.

- Compact Growth Could Adversely Affect The Budgets of Those On Low or Fixed Incomes Now Living In The Urban Areas.

The compact growth policies that depend on rebuilding and renovation of substandard housing could affect the cost of living of minorities and low-income people living in those areas now.

Two "reverse migration" phenomena could contribute to a rise in cost of living. First, older neighborhoods are revitalized as a result of both public sector and private sector efforts. The new inner city image, amenities, convenience etc. attracts middle-income, frequently young white professional people back to inner-city living. They are usually followed by a segment of the retail and service commercial sector keyed to this new inner-city buying public and their higher buying power and different consumer needs (or desires). The new middle-income residents compete with the already established lower-income people for housing, and housing prices rise. The new commercial establishments compete for commercial space with the older established businesses that previously were keyed to the needs of the lower income residents. Thus the price of both housing and consumer goods trends upward in the face of the new market situation.

The frequent result is that the economic changes--as well as social changes--forces the low income residents to look elsewhere. First, they would look elsewhere for consumer goods they need and can afford, which may require travel to another neighborhood. And finally, elsewhere for housing they can afford.

The situation described above is hypothetical in scale but very real in impact for an unknown number of individual households. Its effects will be felt whether compact growth is implemented or not. Current local programs encourage the same phenomena but to a lesser degree.

If compact growth is implemeted, it is estimated that approximately 25,000 more households would locate in rebuilt inner-urban neighborhoods over the 25 year period from 1975-2000. Spread among the 1.5 million households now in these urban neighborhoods, they might seem insignificant in number. However, they too tend to concentrate in specific areas to their particular liking. Thus relatively few inner-city neighborhoods would feel severe effects. They key is whether they would tip the economic scales and alter the economic character of the neighborhood.

- <u>Compact Growth Could Expand Transit Availability For Transit-Dependent Residents</u>.

A compact growth development pattern would not, in and of itself, expand transit availability. It should encourage increased density of development which could better support improved transit service. As indicated in Section VII, increased densities, especially in suburban areas, could reach a threshold where transit use could be expected to increase rapidly. This increase in use could prompt increased service. But, as also indicated in Section XI, this is a case of bringing people to the transit not bringing transit to the people.

Assuming that the highest concentrations of transit dependent residents are living in the areas that would experience significant growth through carrying out the compact growth policies (i.e. in the urbanized areas), whether any change occurs in transit service for the transit dependent will depend mainly on whether the new residents will (more effectively) demand the services for which those who are transit dependent have the greatest need. The transit needs of the transit dependent (i.e. those on low or fixed incomes) may differ substantially from the needs of the new residents, especially if the new residents have higher incomes. The transit dependent generally need intra-community transit (i.e. to health and community centers, neighborhood financial services and shopping facilities). New residents with higher incomes will primarily be interested in transit service to and from work. The new, higher income resident may be able to effectively use the political process to influence transit improvements. Ripple effects may benefit the transit dependent.

Fare box revenues as a proportion of total transit system revenues ought to increase with the influx of new residents into the urbanized areas. More frequent service (although not necessarily new routes) could be anticipated, assuming that the added ridership could not be accommodated by the existing (often underutilized) capacity of the transit service.

The lower density, more dispersed development that would occur under the current local programs could indirectly result in less efficient transit service in the urban areas. This result would occur as new highway construction needs compete with transit needs for limited discretionary transportation funds. Continued restrictions on the use of grant funds for transit operating expenses, and declining urban area fare box revenues (due to continued out-migration of the urban population), would no doubt result in little interruption of the declining urban area transit use/service spiral that has forced its decline since the late 1940s.

Thus, it is not so much a case of what compact growth would do for transit service and the transit dependent, but rather a case of the other choice--low density sprawl--continuing the clear effects of recent decades: declining transit service.

- **Compact Growth Could Broaden Housing Opportunities If Lower Per Housing Unit Costs Are Reflected in the Costs of Housing.**

The proposition that access to the traditionally aspired-to single-family housing market is slipping beyond the economic reach of most low to middle-income households is generally accepted. Even taking into account the income contributions of additional members of the typical household, it is apparent that many households are below the $25,300 to $30,100 income range estimated as necessary to purchase new single-family homes in urban areas (or the $24,300 to $28,350 in suburban areas). Within the more urbanized part of the Bay Region, the San Francisco-Oakland and San Jose Standard Metropolitan Statistical areas, the 1970 median family incomes expressed in 1977 dollar were $18,235 and $19,245 respectively. This indicates that for as many as half, and probably many more, of the families living in those areas, the conventional single-family home on a large lot, presumably in the suburbs, is already beyond economic reach.

Compact growth would encourage construction of more apartments and small-lot single-family homes to create more opportunities for housing and jobs to locate closer together. It could also have the effect of encouraging the construction of more housing that costs less to build and which might be within the reach of middle and lower income households. This assumes that lower building costs could reduce the overall increases in housing costs and would be reflected in the price of housing and rents.

The features of compact growth that could result in lower per unit costs for a broader segment of the new housing units built are the encouragement of more urban area housing and higher density housing in both urban and suburban areas. Urban area land costs would, of course, be higher but with smaller lots land costs would be a lesser part of the total housing package. Also, building in urban areas where urban service capacities already exist could reduce costs.

Three types of higher density housing are less costly to construct, on a per unit basis, than the conventional single-family home, and thus more likely within reach of lower and middle income households. The estimated total per unit costs of construction are: $52,000 - single-family, $46,000 - townhouse, $35,000 - walk-up apartment and $55,000-elevator apartment (excludes land, special site preparation costs and developers profit for 450 typical units in an urbanized area).[1]

The townhouse--or single-family attached home, which is sometimes classified as multi-family because its common-wall features seem to make it part of a multi-unit structure--is estimated to be within reach of purchase in the income range of $19,200 to 22,400. It is estimated that current local zoning regulations and programs for urban services would enable the construction of about 82,000 townhouse units over the next 25 years. Compact growth would encourage the construction of an additional 27,000 townhouse units over that time period.

Walk-up apartment units--usally in apartment houses up to three stories high and containing up to 20 units per structure-- is estimated to be within the reach (purchase) of an income range of \$12,900 to \$15,050. Current local programs would enable the construction of about 73,000 new walk-up apartment units over the next 25 years. Compact growth would encourage the construction of about 28,000 <u>more</u> walk-up apartment units over that same time period.

The following tables show the average market values estimated for four housing types, the estimated income ranges for purchase of each housing type and the estimated rental ranges for each housing type.

Table XIV-3

Comparison of Average Per Unit Market Value, Income Needed to Purchase and Rental Ranges for Four Housing Types in An Urban Area

Housing Type	Average Market Value[a]	Minimum Income Needed to Purchase[b]	Rental Range[c]
Single-Family	\$86,000	\$25,800 - \$30,100	\$540 - \$600
Town House	64,000	19,200 - 22,400	400 - 460
Walk-Up Apartment	43,000	12,900 - 15,050	270 - 300
Elevator Apartment	61,000[d]	18,300 - 21,350	381 - 450

[a]Estimated on a per unit basis for 1977 within an urban area.

[b]Estimated using range of 30-35% of market value.

[c]Estimated assuming rent represents 25% of income.

[d]Elevator apartment costs will drop as higher densities in higher land value areas are chosen for development. This was not generally assumed under compact development.

Table XIV-4

Comparison of Average Per Unit Market Value, Income Needed to Purchase and Rental Ranges for Four Housing Types in A Suburban Area

Housing Type	Average Market Value[a]	Minimum Income Needed to Purchase[b]	Rental Range[c]
Single-Family	$81,000	$24,300 - $28,350	$506 - $596
Town House	62,000	18,600 - 21,700	388 - 452
Walk-Up Apartment	42,000	12,600 - 14,700	263 - 306
Elevator Apartment	61,000[d]	18,300 - 21,350	381 - 450

[a]Estimated on a per unit basis for 1977 within a suburban area.

[b]Estimated using a range of 30-35% of market value.

[c]Estimated assuming rent represents 25% of income.

[d]Elevator apartment costs will drop as higher densities in higher land value areas are chosen for development. This was not generally assumed under compact development.

To indicate the relative buying power necessary to purchase or rent housing expressed in 1977 dollars, median incomes in the San Francisco-Oakland and San Jose SMSA's have been updated to 1977 dollars. The 1970 Census data on median incomes was used as the base.

Table XIV-5

MEDIAN FAMILY INCOMES IN THE SAN FRANCISCO-OAKLAND AND SAN JOSE SMSA

	San Francisco-Oakland SMSA		San Jose SMSA	
	1970 Median Family Income[a]	1977 Estimated Median Family Income[b]	1970 Median Family Income	1977 Estimated Median Family Income
All Families	$11,799	$18,235	$12,453	$19,245
Hispanic Families	$10,459	$16,164	$10,027	$15,496
Black Families	$ 7,966	$12,311	$10,675	$16,498

[a]These are 1969 dollars

[b]Estimated using the San Francisco-Oakland Consumer Price Index

Comparison of the information presented in Table IV-3 through IV-5 results in several conclusions. Based on the estimated incomes necessary to purchase new single family housing at the market values noted, families with incomes just above the estimated median family income level (half of the population) would prebably be able to afford to purchase* a new single-family unit in a suburban area, but not in an urban area. Families with incomes below the median (half of the Bay area population) and Hispanic and Black families with incomes just above or below the median incomes estimated for those groups would probably not be able to purchase a new single family unit in either location. These conclusions generally reflect the current market situation where single-family housing is becomming more and more inaccessible to a large portion of the Bay area population. Therefore, the estimated market values for typical new single family units which reflect compact development do not worsen the accessability/affordability situation. Nor do they better the situation.

Reviewing the information in the tables with respect to townhouses results in somewhat different conclusions. Families in the 3 categories whose incomes bracket the median family incomes noted (with the possible exception of Hispanics in the San Jose SMSA;Blacks in the San Francisco-Oakland SMSA) would probably be able to afford to purchase or rent new townhouse units in either of the areas for which estimated costs were calculated. As compact growth would allow construction of one-third again as many townhouses as would be constructed under current programs, housing opportunities for families bracketing the median incomes estimated for the three categories should experience improved housing opportunities.

Using the Department of Housing and Urban Development (HUD) definition of low-income (households with incomes less than 80% of the median family income), families with incomes below $14,588 in the San Francisco-Oakland SMSA and $15,396 in the San Jose SMSA would be considered low-income families.+ Based on the estimated incomes needed to purchase, low-income families would probably not be able to purchase or rent new townhouses (at the estimated market values noted for urban and suburban areas) without assistance through programs such as the HUD Section 8 Housing Assistance Program and Section 235 homeownership program, and the California Housing Finance Agency programs.

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*Throughout this discussion, conclusions about the ability to purchase are based solely on the relationship between estimated median income levels and estimated income needed to purchase. This does not account for (Although the importance is hereby recognized) determining factors such as the amount of initial cash outlay required, the amount of the monthly obligations (mortgage) thereafter, the ability to qualify for a loan and maintenance costs.

+This estimate is provided as a frame of reference only to aid in the assessment. Actual low-income levels would be adjusted to reflect the effect of factors such as household size.

The funds available through these programs are, however, limitied. Compact growth would allow the construction of more townhouse units than would be the case under current programs. As noted, the information in the tables suggests that the new townhouse units (at the estimated market values) would be affordable by about half of the Bay area population. If a large protion of the population could afford to purchase or rent townhouses and the number of such units increases under compact growth, housing opportunities for low-income households could improve additionally through a "rippling" effect.

Reviewing the information in the tables with respect to walk-up apartments results in still different conclusions. Families with incomes somewhat below the estimated median incomes noted should be able to afford to rent (assuming few would purchase) walk-up apartments at the estimated market values. Using the HUD definition of low-income again, families considered low-income families should also be able to afford to rent these new walk-up apartments. As compact growth would allow the construction of 28,000 more walk-up apartment units than would be the case under current programs, rental housing opportunities for low-income families should increase. These groups should also benefit from the "rippling" effects of more new walk-up apartment units in the market.

Most families that bracket the estimated median income levels (again with the exception of Hispanic families in San Jose SMSA and Black families in the San Francisco-Oakland SMSA) should be able to afford to rent in new elevator apartment units priced at the estimated market values noted. Low-income families would not be able to afford to rent in new elevator apartment units priced at the estimated market values. However, thoses estimates were not based on construction in higher land value areas. Generally, higher land prices result in more attractive prices for elevator apartments.

In summary, compact growth results in new townhouses and walk-up apartments being affordable by many low and middle-incme families. New walk-up apartments are particularly feasible for low-income families although some families would still need subsidies. Elevator apartments, which are not generally assumed at higher densities under compact growth, would become more attractive if developed in higher land value areas. As more townhouses, walk-up and elevator apartments would be availalbe to all segments of the population, other housing opportunities could arise for the low-income family through a "rippling" effect.

FOOTNOTES

[1] Lee Saylor Inc. Housing Costs, EMTF Special Study Prepared for the Association of Bay Area Governments, January 5, 1978.

Appendix A

DESCRIPTIVE

URBAN/SUBURBAN AREAS OF THE BAY REGION

Attached Figure 1 displays the aggregate "urban" and "suburban" areas used in the text and tabular information to describe the differences between the base case of current local policies and programs and the compact growth alternative. These geographic indicators are not intended as recommendations of what an area ought to be. They simply indicate that locales in these areas share certain characteristics now, describable as urban or suburban. They will likely remain similar in characteristic--and distinct from each other--regardless of whether current development policy or the recommended compact development policy is carried out.

This indication of different types of subregional areas is used to summarize descriptions of the degree of differences between the alternatives being considered. The differences can be described in terms of the objectives of the compact growth alternative: to shift the emphasis of new land development from the outlying areas beyond urban services back to the already urban areas. However, the indicators are based on the areas' development potential under current local policies and programs.

Areas described as <u>suburban</u> are partially developed now, usually at low densities; have extensive vacant acreage proposed for development most of which lacks commitments for urban services, and have minimal transit service. Areas described <u>urban</u> are highly developed now, at relatively high densities; usually have some vacant acreage proposed for development most of which has urban services now or such service is committed; and in most cases have rail transit service now, and/or established bus transit service.

The areas are aggregates of census tracts which were scaled against the criteria set out in Table A below to establish general subcounty areas of similar characteristics. The criteria were not applied rigidly but were used as guidelines to group localities which are similar in terms of existing development characteristics as well as similar in development potential.

Table A

CRITERIA FOR DESIGNATING
DESCRIPTIVE URBAN/SUBURBAN AREAS

Factor Considered	Urban	Suburban
1) Inside/outside of a LAFCO defined city sphere of influence[a]	90%-100% inside city sphere	33% to 90% inside city sphere
2) Ratio of developed area to total	75% to 100% developed	10% to 25% developed
3) Proportion of vacant land not developable under local regulation	less than 10%	10% to 50%
4) Proportion of vacant developable land by status of urban services (sewer and water)		
a) Full services exist...	for 75% to 100% of developable land	for 0 to 25% of developable land
b) Services committed in Capital Programs...	for 50% to 75% of developable land	for 10% to 50% of developable land
c) Zoned for development but no service commitments...	for less than 50% of developable land	for 50% to 90% of developable land
5) Transit service	In rail tranist corridor and/or local bus service	Express bus service (commuter) only
6) On-ground residential density	7 dwelling units/acre or greater	1 to 7 dwelling units/acre
7) Existing ratio of jobs to housing	1.25 jobs per household	.5 to 1.25 jobs per household

[a] In Santa Clara, LAFCO defined urban service areas. In Sonoma where the LAFCO has not yet adopted city sheres of influence the line of demarcation is city general plan areas as recognized by city and county planning staffs.

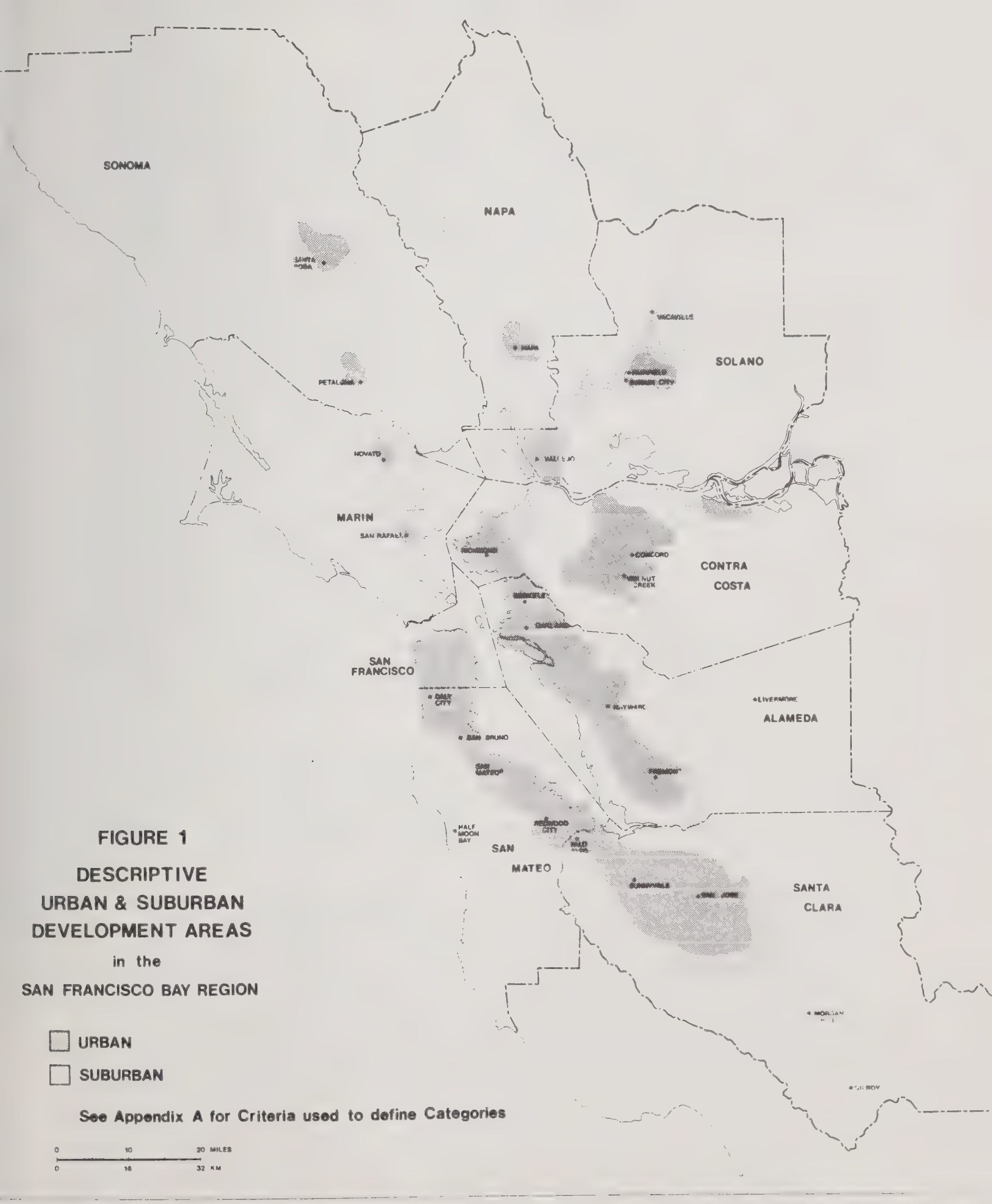

FIGURE 1

DESCRIPTIVE
URBAN & SUBURBAN
DEVELOPMENT AREAS
in the
SAN FRANCISCO BAY REGION

See Appendix A for Criteria used to define Categories

APPENDIX B
GLOSSARY OF TERMS

Terms noted in quotation marks are found elsewhere in the glossary.

ADDITIONAL INCENTIVE (PROGRAMS) - Additional incentives offered by a local jurisdiction to encourage land development. Above and beyond simply zoning land for a particular type of development. Examples include financial commitments for needed capital facilities such as streets, sewer lines, etc.; formation of assessment districts to finance needed services or facilities, etc.

(PRIME) AGRICULTURAL LAND - Prime agricultural land in the sense of soil type. (Class I or Class II in U.S. Soil Conservation Service land use capability classifications.) The land is not necessarily in active agricultural use at this time. Both "alternatives" account separately for (Williamson Act) Agricultural Preserves which may or may not involve prime agricultural land.

AUTO DEPENDENCY - Being dependent upon the automobile for necessary personal trips from home to work, to shopping, to school, to recreation, etc. Such dependence usually occurs because of alternative modes of travel such as transit or walking are not available; or are impractical or impossible because of the distances or travel time involved. Frequently the case in low density, exclusively one land use type neighborhoods where the auto is essential to conduct normal day-to-day activities (e.g., the "bedroom" suburb where shopping, school, work are miles away; or the extensive exclusively industrial district where retail or service needs of either the workers or the business itself are an auto-trip away).

ALTERNATIVES - Alternative courses of action. The two alternatives being considered here are: Current Programs and Compact Growth, both more fully defined below. Current Programs is the aggregate package of local land development regulations and service programs that is now in effect. Compact Growth is the alternative package of such regulations and service policies analyzed in the AQMP.

BALANCE OF HOUSING & JOBS - That proportion of housing, commerce and industry within a jurisdiction or a subregional grouping of jurisdictions that will minimize the need for interjurisdictional travel--especially commuter travel. The degree of imbalance is analyzed in the AQMP on the basis of the net difference between jobs and employed residents in the given area. No absolute quantitative "balance" is advocated other than assessment of each alternative to determine if the degree of balance or imbalance that already exists is likely to improve or worsen.

BUS TRANSIT - For purposes of this assessment includes all forms of non-rail transit. Some distinction is made between general local bus service (frequent stops for both boarding and getting off) and express bus service (long distance express service from a single origin/destination, such as a job center or BART station, to a distant series of stops). Local service generally favors many trip purposes within the jurisdiction or sub-area. Express service generally favors long-distance inter-jurisdiction commuting trips.

COMMITTED (URBAN) SERVICES - For this assessment generally limited to sanitary sewer service and water service. Areas described as having committed services are those where whichever service is not now in effect (in some cases both) that service is committed in the Capital Improvements Program of the service agency having jurisdiction.

COMPACT GROWTH (or Compact Development) - A pattern of land development that would occur by encouraging or requiring that building occur first where urban services exist or are committed, and at densities consistent with such services, including densities that would be more "transit supportive".

CONVENTIONAL SINGLE FAMILY (RESIDENCE) - A single family detached residential structure on a separate large lot. The lot size is generally .21 acre or larger (e.g., lot measuring 60' X 150' or larger). Net density is under 5.0 dwelling units/acre. Gross density (incicluding streets, etc.) is under 4.0 dwelling units/acre.

CURRENT LOCAL REGULATIONS - Local regulations now in effect that directly affect land development and building. For the most part zoning but also including subdivision, permit moratoria, and other actions that determine where, when, and how building will or will not occur.

CURRENT PROGRAMS - A general term used in this assessment to mean the aggregate of local land regulations and service programs now in effect.

DENSITY, HIGH(ER) - As used here, generally refers to residential development of higher density than "conventional single family"--higher than 5.0 dwelling units per net acre, involving either so-called "townhouses" or apartments. In the context of discussion of "multi-family" residences may refer to apartments (greater than 22 dwelling units/net acre) as differentiated from "townhouse" type development.

DENSITY, LOW(ER) - As used here, generally refers to "conventional single family" residential development--lower than 5.0 dwelling units/net acre. In the context of discussion of single-family residences may refer to single-family residential development in locations without sewer and/or water service where lower generally implies densities of less than 1.0 dwelling units/net acre.

DENSITY RANGE - Most zoning ordinances establish ranges of permitted densities for specific locations rather than one specific target density. The analysis of both alternatives ("current programs" and "compact growth") assumed the top 1/3 of the range, or the absolute top of the range, based on advice of the jurisdiction or the county lead agency.

DENSITY SHIFT - Compact growth analysis assumed a shift to a higher average density in locations with existing or committed sewer, water, and transit service. In no case was the shift so severe as to constitute a shift in housing type as defined here.

DISLOCATION - The temporary or permanent dislocation of residents or establishments now located in a given neighborhood.

DOWNZONING - Rezoning of a neighborhood or area to a lower residential density than is permitted there now. In older city neighborhoods zoning enacted decades ago frequently permits much higher densities than exists there now. Actions to lower the permitted densities consistent with the existing situation--usually for purposes of preserving neighborhood character--is not necessarily inconsistent with the objective of compact growth. Rezoning to disallow building at densities as high as already exists would be inconsistent with compact growth.

ELEVATOR APARTMENT - A residential structure of 6 or more stories. The density is 46 or more units/net acre. Could include two subcategories: Mid-rise, 6 to 11 stories, 46 to 99 units/net acre; and High-rise, 12 or more stories and 100 or more units/net acre.

EXCESS CAPACITY - Condition where an essential urban service (sewer or water service) has more capacity than is now used, or insome cases, more than may be needed in the future. Excess existing capacity refers to usused capacity that now exists. Excess planned capacity refers to capacity that is planned but not yet built which was based on higher growth assumptions than now appear plausible due to changing conditions.

HIGH DENSITY HOUSING - Generally refers to "multi-family" residential areas, or more specifically apartment districts ("walk-up apartments" and "elevator apartments").

HOUSEHOLD - A socio/economic unit including families, individuals, or groups of unrelated individuals who occupy a housing unit.

HOUSING DEMAND - Refers to a major component of housing demand but not to total housing demand. Includes demand for new housing by new households. Does not account for demand for improved quality housing by existing households. Assumes households have financial capacity to purchase or lease housing.

HOUSING POTENTIAL - The total potential "sites" on which housing could be built under either "current programs" or "compact growth", assuming any number of households less than or equal to the number of "sites".

HOUSING SITES - Land sites on which housing can be built consistent with assumptions about zoning density and when and where urban services will be provided. One housing site represents potential for one housing unit.

HOUSING SUPPLY - New housing supply refers to the yet to be built supply of new housing that would accommodate new households during the period from 1975 to 2000. Does not account for vacancy. Existing housing supply refers to the housing stock as it existed in 1975 in terms of quantity, including vacancy, but not accounting for quality.

HOUSING TYPE - Four housing types are identified and specifically accounted for in the assessment: 1) "Conventional Single Family", 2) "Townhouse or Clustered", 3) "Walk-up Apartment", 4) "Elevator Apartments". Each type is further defined elsewhere in this glossary.

HOUSING UNITS (OCCUPIED) - Houses, apartments, groups of rooms, or single rooms which are occupied and the occupants live and eat separately from other persons in the structure, have direct access to the units, and have complete kitchen facilities for the occupant's exclusive use.

IMPACTS - Impacts are quantitatively measured and/or qualitatively assessed in terms of the difference between what would likely occur with compact growth and what would likely occur assuming current local regulations and urban service programs.

INFILL - Refers to development of scattered vacant parcels within the developed urban--and to some extent, suburban--areas where urban services already exist or are committed. The sites in question have been bypassed by previous development for reasons that can only be speculated on: 1) not available by present owners for development (perhaps speculation); 2) not developable for physical reasons unique to the site (too small, inaccessible, unstable slopes, soil problems, etc). Includes land zoned for residential use, estimated to be from 10,000 to 40,000 acres regionwide. Could include vacant land zoned for non-residential use (e.g., industrial or commercial) which has not proven attractive for development up to now, and which exceeds the anticipated needs for non-residential development. Such urban area industrial-zoned vacant land is estimated to be about 25,000 acres.

JURISDICTIONS - Includes unincorporated communities such as Castro Valley or East Palo Alto as well as cities. Unincorporated area adjacent to a city but within LAFCO adopted "sphere of influence" assumed to be within city's eventual jurisdiction and thus subject to city's policy.

LAFCO - Local Agency Formation Commission. Joint city/county agency in all eight counties outside San Francisco. LAFCOs are mandated to establish "spheres of influence" for all cities and special districts as well. LAFCOs determine annexation to cities and districts as well as rule on formations, consolidations, etc.

LONG-TERM FUTURE - Time period from 1985 to 2000 when compact growth and transit recommendations of AQMP would begin to have most noticeable effect.

LOW INCOME HOUSEHOLD - There are two commonly used definitions. The Bureau of Census, Poverty Statistics office definition is (1977) $6190 threshold income for a family of four. The Department of Housing and Urban Development defines low-income as households with an income which is less than 80% of median income. The 1970 Census information for the San Francisco-Oakland SMSA lists the median income as $11,799 per year. Using the HUD definition all households in the SMSA with incomes less than $9439/year would be defined as low income households.

MULTI-FAMILY HOUSING - Generally refers to apartment units, including "walk-up apartments" and "elevator apartments" (see elsewhere in this glossary). In cases where comparisons are being made with historical data, "townhouses" or attached single-family units are included since data on building permits groups these units with "multi-family" housing because of their common-wall features which make them appear to be part of a multi-unit structure.

OUTLYING AREAS - Generally refers to "suburban areas" or "rural areas" beyond the reach of existing or "committed" "urban services".

PHOTOCHEMICAL OXIDANTS - Secondary pollutants formed by the action of sunlight on the oxides of nitrogen and hydrocarbons in the air: they are primary contributors to photochemical smog, an eye-irritating atmospheric condition.

PLANNED UNIT DEVELOPMENT (PUD) - A unified land development which is excluded from the general setback, yard, and height regulations of the zoning code and thus produces clustering of development. Usually results in common open space area and frequently includes commercial and public facilities to serve the residents.

RAIL TRANSIT - Refers primarily to existing BART and Southern Pacific Railroad systems and commuter rail service. Accounts for San Francisco MUNI rail system improvements that are committed but not yet in service. Does not account for any other local rail transit systems that may be in planning stages but not financially committed.

REBUILDING - Refers to rebuilding of residential and/or commercial structures, either standard or substandard in quality which may involve a net increase or decrease in the number of housing units. Includes conversions or "restoration" of existing structures which may involve a net increase or decrease in the number of housing units. Excludes "rehabilitation" or "restoration" which does not involve a net increase or decrease in the number of housing units. Permanent "dislocation" of residents highly probable.

APPENDIX C
RECOMMENDED POLICIES AND ACTIONS TO ACHIEVE COMPACT GROWTH

The following policy and action recommendations constitute General Policy IV of the Air Quality Management Plan Recommendations.

IV. General Policy: Alter regionwide development patterns to reduce automobile travel by means of local and regional policies on land use and urban services.

Analysis of development trends in the Bay Area shows that distances between home, work, shopping, school and recreation are increasing in ways that will cause more serious air pollution. This is because development is becoming ever more scattered, at lower density, with more separation between where people live and where they go. In many fringe areas, development occurs without sewer, water or transit service. Older city areas are bypassed, with little rebuilding or use of vacant land where urban services already exist or are committed. Densities get even lower because the preponderence of residential construction is for single-family homes on large suburban lots. Densities are also getting lower because of the need for large lots in locations where health and safety dictate it to accommodate use of septic tanks and wells, as well as to enable building on steeper slopes. The pattern of urban sprawl results in increasing dependence on the automobile. More people must use the auto for more purposes at even greater distances. The policy suggested is to reduce auto dependency and thereby improve air quality.

The general policy stated above has 16 more specific policies and 49 actions indicating what government agencies would need to do to alter development patterns to bring about more compact development. The policies and actions include adopting urban services areas, extending development consistent with those areas, building on bypassed land within existing areas. They also involve encouraging densities consistent with earlier local practice (e.g., the 1900s and 1930s), and would allow in certain instances mixed residential, commercial and industrial areas. They also would mean adopting programs to reduce the imbalance between jobs and housing throughout the region, so that distances between jobs and homes can be shortened. The compact growth policies and actions described in this chapter would reduce automobile emissions and improve air quality. They are a more precise statement of the city-centered policy adopted by the ABAG General Assembly in the Regional Plan of 1970 and the General Assembly's growth policy actions of 1973 and 1974. Some of the policies and actions are already being carried out by some local jurisdictions in the Bay Area. Not all actions would be required of every city and county--or every public agency involved. Specific actions would be determined in cooperation with the jurisdictions involved in the first and subsequent years of the continuing planning process.

The policies and actions are as follows:

Policy A: Extend new development only to those locations with existing sewer and water service or sewer and water service committed in capital improvement programs.

Action 1: Local Agency Formation Commissions (LAFCOs) adopt city and special district spheres of influence throughout the region as soon as possible.

Action 2: LAFCOs adopt the "urban service area" concept for defining urban service commitments and projecting urban land needs for 5, 10 and 20 year periods.

Action 3: LAFCOs approve annexations and formation of cities and special districts consistent with Action 2 findings on urban service commitments and urban land needs.

Action 4: Counties and cities enact non-urban zoning outside urban service areas.

Action 5: Counties and cities enact temporary moratoria on urban zoning and subdivisions outside urban service areas pending the enforcement of non-urban zoning in such areas.

Policy B: Restrict development outside urban service areas in areas of critical environmental concern (environmental resources, hazards, of amenities).

Action 6: Counties and cities enact agricultural zoning or large-lot rural residential zoning (generally one dwelling unit per 40 acre minimum lot size).

Action 7: Counties and cities initiate, continue or expand programs under the California Land Conservation Act (Williamson Act), the Open Space Easement Act of 1974 and the Z'berg-Warren-Keene-Collier Forest Taxation Reform Act of 1976 outside urban service areas.

Action 8: Counties and cities establish programs of public land management (including acquisition, purchase/leaseback, purchase/transfer of development rights, etc.) for locations outside urban service areas.

Policy C: Develop unimproved land within urban service areas where urban services exist or are committed in capital improvement programs.

Action 9: ABAG, counties, cities and LAFCOs establish "early warning" inter-agency information exchange programs concerning urban service facility plans at the earliest stages of project planning.

Action 10: Expedite city, county, LAFCO or ABAG project reviews where needed information on service capacities has been provided under Action 9 above.

Action 11: Counties and cities initiate rezoning and permit preference procedures in locations with existing but unused service capacities (with emphasis on water, sewer, transportation and school services).

Policy D: Complete, as soon as possible, all needed sewer, water or transportation service improvements within adopted urban service areas.

Action 12: LAFCOs review all city, county, or special district sewer, water, or transportation service capital improvement programs and report on priority needs within each urban service area.

Action 13: ABAG review sewer, water and transportation needs within all urban service areas to determine region-wide priorities among such service needs.

Action 14: ABAG favorably review applications for State/Federal financial assistance from agencies lacking service capacity within urban service areas, where other existing or committed services have been found by the LAFCO to be capable of accommodating additional development.

Policy E: Improve highway, street, road and transit systems consistent with local actions to stage land development.

Action 15: Counties and cities enact planning and zoning regulations to stage land development consistent with the scheduling of urban services (including but not limited to "development sequence zoning", "tiered zoning districts", development timing permits etc.).

Action 16: Caltrans, MTC, counties, cities, and special districts plan, program, fund and construct highway, street, road and transit improvements consistent with local action to stage land development.

Policy F: Increase housing and job opportunities in existing urbanized areas by encouraging public and private rebuilding into compatibly mixed commercial, industrial and residential land uses.

Action 17: Counties and cities initiate and/or expand housing conservation programs in existing urbanized areas.

Action 18: Counties and cities initiate and/or expand commercial and industrial development and redevelopment in existing urbanized areas.

Action 19: Counties, cities and special districts initiate and/or expand incentives to public and private redevelopment in urbanized areas. Emphasis would be on sewer and water facilities, and extensive transit service improvements, but should also include educational and cultural facilities and public safety service improvements where appropriate.

Action 20: ABAG, counties and cities analyze possible local revenue reforms to provide adequate financial resources to carry out Action 19.

Action 21: ABAG support State legislation to provide local governments with adeuqate fiscal resources to carry out Action 19.

Action 22: ABAG oppose Federal and State legislation that would hamper the ability of local governments to carry out rebuilding programs to increase job and housing opportunities in existing urbanized areas.

Policy G: Encourage "infill" development of bypassed vacant land within urban service areas.

Action 23: Counties and cities undertake planning studies to inventory bypassed land, identify development problems, and resolve questions of best potential use.

Action 24: Counties and cities adopt necessary changes in zoning and permit procedures to facilitate development of bypassed parcels affected by special conditions.

Action 25: Service agencies design sewer, water and transportation systems to improve accessibility and service ability of bypassed vacant land in existing urban communities.

Policy H: Develop at higher densities within service areas where existing or committed urban service capacities, including transit, can support the higher densities.

Action 26: In urban service areas with adequate sewer, water and transit capacities, counties and cities rezone appropriate locations to permit higher densities.

Action 27: Counties and cities enact ordinances (such as those for planned unit development or cluster zoning) to foster higher densities on appropriate sites.

Policy I: Limit development of land within urban service areas where soil, slope, or other conditions can support only low-density development.

Action 28: Counties, cities and special districts deny primary urban services to these locations by excluding them from capital improvement programs and design of service systems, and by enactment of hookup moratoria, etc.

Action 29: Counties and cities and special districts establish programs of public land management (including but not limited to public land acquisition, purchase/transfer of development rights, purchase/leaseback, etc.) to maintain appropriate sites in open uses.

Policy J: Improve the balance of jobs and housing in jurisdictions throughout the region to reduce the necessity for long distance home-to-job travel.

Action 30: Cities and counties adopt programs to increase local employment opportunities if a substantial proportion of their residents work elsewhere.

Action 31: Cities and counties adopt programs to increase local housing opportunities in a price range suitable for their work forces if a substantial proportion of their work forces live elsewhere.

Action 32: ABAG conduct A-95 and EIR reviews to support local government efforts to improve the balance of jobs and housing in communities throughout the region.

Action 33: ABAG support State and Federal funding allocations for facilities and programs offering incentives to economic development or housing development in appropriate jurisdictions.

Policy K: Mix residential/commercial and industrial development in communities throughout the Bay Region.

Action 34: Counties and cities revise zoning ordinances to allow compatible mixtures of land uses with adequate design or performance standards (including planned unit developments, performance standards, zoning, etc.).

Action 35: Counties and cities expand application of conditional use permits where appropriate.

Policy L: Discourage new large-scale land development projects that are exclusively commercial, industrial or residential, unless such projects clearly demonstrate that they improve the overall balance of jobs and housing in that city, county, or subregion.

Action 36: Counties, cities and LAFCOs deny incorporation or annexation of large-scale development proposals that are exclusively commerical, industrial or residential, unless such incorporation or annexation can be shown to improve the overall balance of jobs and housing in the city, county or subregion.

Action 37: MTC, the California Department of Transportation and transportation districts deny regional transportation system access or extension to proposed large-scale land development projects that are exclusively commercial, industrial or residential unless such transportation actions can be shown to improve the overall balance of jobs and housing in the city, county or subregion.

Policy M: Fund new wastewater and transportation facilities only after areas serviced have taken actions recommended in the plan.

Action 38: The State Water Resources Control Board and the Environmental Protection Agency require applicants for wastewater facilities under Section 201 of the Federal Water Pollution Control Act to demonstrate, prior to construction funding, that specific actions (including but not limited to land development regulations, urban service commitments, etc.) have been taken by affected jurisdictions to carry out actions of this plan.

Action 39: The U.S. Department of Transportation, the California Transportation Commission, the California Department of Transportation and the Metropolitan Transportation Commission require applicants for transportation improvement grants to demonstrate, prior to funding for acquisition and construction that specific actions (including but not limited to land development regulations, urban service commitments, etc.) have been taken by affected jurisdictions to carry out actions of this plan.

Policy N: Review development proposals for air quality effects and consistency with compact development (indirect source review).

Indirect sources of air pollution are sources that do not directly emit pollutants, but which inlcude emissions from other sources (primarily motor vehicles). An Indirect Source Review program would be

used for two purposes: First, to ensure consistent application of the compact development policies; and second, to prevent localized carbon monoxide problems in the vicinity of the indirect source.

The types of new or modified sources to be reviewed for approval under this measure would include, but would not be limited to, the following:

- Highways and roads;
- Parking facilities;
- Retail, commercial, and industrial facilities;
- Recreation, amusement, sports, and entertainment facilities;
- Airports;
- Office and government buildings;
- Apartment and condominium buildings;
- Education facilities.

The above sources would include most large projects.

The review procedure would be limited, however, to developments above certain size thresholds, specified in terms of daily traffic volumes for highways, annual aircraft operations for airports, and number of parking spaces for most other facilities. Indirect sources smaller than the threshold sizes are assumed to be evaluated and controlled as part of the overall compact development strategy.

Action 40: ABAG, BAAPCD and MTC adopt memoranda of understanding and procedures for prompt and thorough joint review of significant development proposals. Review would be conducted for proposals (such as shopping centers, industrial parks, office complexes, etc.) where significant air pollution could result from the project's generation of auto traffic.

Action 41: BAAPCD adopt permit procedures for application to indirect sources.

Action 42: ABAG encourage and support local government efforts to determine direct and indirect effects on air quality in making local land use decisions. Such support shall include technical assistance and analysis.

Action 43: ABAG and MTC encourage and support local government efforts to reduce adverse effects of development proposals on air quality, including but not limited to assistance in identifying and implementing mitigation measures for adverse impacts of municipal wastewater facilities and transportation improvement programs.

Policy O: Adopt financial programs to support local and regional agency actions and private sector development actions consistent with policies in this chapter to reduce home-to-work distance and auto dependency.

Action 44: ABAG, counties and cities support State and Federal legislation to provide subventions and other fiscal assistance to cities and counties carrying out development policies to achieve air quality standards.

Action 45: ABAG, counties and cities support State and Federal legislation providing tax incentives to the private sector for rebuilding and development within existing urbanized areas.

Action 46: ABAG, counties and cities support State and Federal legislation providing financial support to local and regional agencies for carrying out development management policies and reviews to achieve air quality standards, especially to mitigate adverse impacts on low- and moderate-income households.

Policy P: Adopt a coordinated regionwide program for carrying out actions for attainment and maintenance of air quality standards through development and land use management actions by cities, counties, special districts, ABAG, BAAPCD, MTC, LAFCOs and other appropriate local and regional agencies.

Action 47: ABAG identify, within six months of General Assembly adoption of an initial air quality maintenance plan, which implementing actions are being carried out by local and regional agencies.

Action 48: ABAG include, in each annual revision of the AQMP, agreements reached among local and regional agencies for carrying out land use and development management actions included in the initial AQMP.

Action 49: ABAG shall include, in each annual revision of the AQMP, an identification of actions not being carried out by all appropriate agencies, and which actions are to be carried out by appropriate agencies by the next annual revision of the AQMP.

AQMP/ Tech Memo 16 September 1977

INSTITUTIONAL, LEGAL AND FINANCIAL REQUIREMENTS FOR IMPLEMENTING PROPOSED AIR POLLUTION CONTROL PROGRAMS

INTRODUCTION

The purpose of this memo is to document the institutional, legal, and financial requirements for carrying out proposed Air Quality Maintenance Plan programs. It is intended to provide a basis for discussing concerns, questions, and issues relevant to AQMP implementation.

The institutional structures necessary to implement most of the proposed AQMP programs are already in existence in the Bay Area. To date, many air pollution controls have been implemented by a variety of agencies at various levels of government and significant air quality improvements have been achieved (Tech Memo 4 - STATUS OF EXISTING CONTROLS RELATED TO AIR POLLUTION). This memo assumes that these entities would implement proposed control program elements for which they have authority. It does not assume that they have all of the authority required to implement the proposed measures. The focus, therefore, is on identifying the legislative/regulatory, organizational, and financial requirements for implementing proposed control measures. Existing powers are identified where such authority to implement control programs already exists. Also, cooperative arrangements believed necessary to carry out the respective programs are briefly discussed.

Many factors besides institutional considerations determine successful implementation of control programs. They are subjects worthy of separate examination and have been discussed in previous memos. (See Tech Memo 14 - Costs and Effectiveness of Control Measures, and Tech Memo 15 - Assessment of Impacts of Control Measures.)

IMPLEMENTING STATIONARY SOURCE CONTROL PROGRAMS

The Role of BAAPCD in the AQMP Program

In California, local and regional authorities have the primary responsibility for control of air pollution from all nonvehicular sources, and may establish stricter standards than those set by law or by the State board. "Nonvehicular sources" means all sources of air contaminants, including the loading of fuel into vehicles, except vehicular sources. Ambient air quality standards are set by the Federal and State governments, but those set by the latter may vary from one air basin to another. The Bay Area Pollution Control District was created by the California Legislature and is the regional air quality agency for the Bay Area.

The District Board of Directors has the power to develop and enforce regulations for the control of air pollution within the District. It appoints a 20-member Advisory Council from community interest groups to advise and assist it in developing regulations. Public hearings are required prior to any action adopting or amending such regulations.

By law, the District is mandated to adopt and enforce rules and regulations which assure that reasonable provision is made to achieve and maintain the ambient air quality standards in its jurisdiction. The District Board is empowered to establish zones wherein special regulations are warranted. The Board is specifically mandated by law to establish standards for the emission of identifiable odor-causing substances. The District may also establish additional standards than those set forth by law or the state board.

Some District regulations directly control air pollution by limiting the emissions of specific contaminants. Others indirectly control pollutants by curtailing open burning, necessitating process changes, or reviewing construction permits. In addition to its regulations the District has the broad power to abate emissions causing a public nuisance.

Regulatory Structure for Implementation of Proposed Stationary Source Controls

Six stationary source control measures were selected primarily because of their effectiveness in reducing air pollution and their technical feasibility of implementation. The control measures are:

1. Use of high solids and water based surface coatings to result in decreased use and evaporation of organic solvents.

2. Closed system organic storage to reduce evaporation from storage.

3. Limiting maximum concentration of SO_2 in any emission to 300 parts per million, equivalent for combustion to fuel S concentration of 0.5%.

4. Limiting maximum concentrations of SO_2 in any emission to 150 parts per million, equivalent for combustion to fuel S concentration of 0.25%.

5. Requiring use of best available control technology on both existing and new sources (BACT).

6. New source review and requirement of offset emission reductions.

All of the measures selected are within the existing authority of the BAAPCD and the California Air Resources Board. However, new or altered regulations will be required; such new regulations or changes to be determined and implemented by the District Board of Directors pursuant to its existing rule making procedure. Board actions likely required to implement the proposed measures are the following:

1. <u>High Solid and Water Base Coatings</u>

A regulation or regulations covering the types of coatings to be used in certain processes. The Board may adopt regulations presently being developed under the State Air Resources Board's Model Organic Solvents Regulation Program or develop similar regulations locally.

2. <u>Closed System Organic Storage</u>

BAAPCD regulations in force require control of organic emissions by a number of means including use of floating roofs, submerged fill pipes, and in some cases vapor recovery units. Floating roofs and submerged fill pipes still allow emissions which could be controlled by closed systems in which vapors are collected and reprocessed to liquid, burned as fuel, or incinerated. Current BAAPCD regulations could be altered by the Board to require closed system storage.

3. <u>Limitation of Emissions to 300 ppm SO_2</u>

4. <u>Limitation of Emissions to 150 ppm SO_2 or Limit Sulfur Content of Fuel to 0.25 wt. %</u>

BAAPCD regulations in force specify SO_2 concentration limits for SO_2 emissions under various circumstances. The District Board could reduce such limits and/or specify the sulfur content of fuel to be used in combustion operations. Development of tail gas scrubbers in recent years has markedly reduced the problem of high concentration SO_2 emissions. Future problems appear more likely to come from increasing use of oil or coal as fuel, thus making specification of an either/or rule with both low sulfur fuel and/or an equivalent low emission concentration practical. Special consideration might be given to high concentration but low volume situations.

Inasmuch as the major concern about SO_2 is for the effects of switching from gas to oil or coal as required by fuel availability, it might be well to consider how fast the regulations should be tightened. It may not be necessary to move immediately to .25% S fuel or 150 parts per million.

5. <u>Best Available Control Technology</u>

A regulation requiring industry to employ the best available control technology on new and existing sources would require careful thought and extensive public hearings. The most probable form of such a rule would incorporate BACT into a permit system, and would work from a catalog of what constitutes BACT in any particular situation. Possibly there would be some flexibility in the application of such a catalog in order to accommodate the wide variety of sizes, forms, design and operation to be found in even limited types of industry. The catalog should be a moving list under constant scrutiny by the District's Advisory Council. Time allowed for compliance by industry and enforcement powers of the District would be determined by the BAAPCD Board of Directors under the law. It is possible that such a regulation would result in numerous cases being brought before the District Hearing Board, especially in the early stages of application of the rule. The authority to specify control equipment, however, has recently been incorporated into the State laws which govern the BAAPCD.

6. New Source Review and Trade-Off

BAAPCD regulations already incorporate a new source review and permit rule which provides for extremely limited trade-off. A new regulation, therefore, is not required. Offset provisions recently proposed by the U.S. Environmental Protection Agency would make more flexible the similar provisions of the District Rule. The EPA Offset policy, or some similar modification, derived locally, should be considered by the District Board.

Institutional and Financial Requirements

The governmental structure for implementing the proposed control measures already exists in the Bay Area Air Pollution Control District. The majority of the measures being proposed simply require more stringent extensions of measures already in force for control of industrial and other stationary sources of air pollution.

The District's capacity for carrying out the proposed measures is augmented by both formal and informal arrangements with other agencies. On the Federal and State levels, the agency maintains interaction with EPA and the Air Resources Board. Areas of contact include technical information, regulatory proceedings, reports and investigations. At the regional level, Memoranda of Understanding serve as appropriate vehicles for closer communication and coordination between the District and a number of agencies including the Metropolitan Transportation Commission and the Association of Bay Area Governments. Interaction at this level will be even more essential if the proposed stationary source programs are to be implemented in concert with other control programs discussed later. District staff have also established frequent and widespread contact with local governments, particularly with local planning and building departments. These contacts, ranging from enforcement matters to permit applications, will be instrumental in implementing the proposed measures.

Because the majority of AQMP measures being proposed are administrative in nature, and essentially require stricter application of existing regulations, financing required to support them should be relatively modest. The imposition of a BACT rule applied extensively would require some expansion of District personnel, especially in the Engineering staff. Inspection and enforcement functions, laboratory and air quality monitoring functions, would remain about as at present. Some temporary increase in Hearing Board activity might be expected.

IMPLEMENTING MOBILE SOURCE CONTROL PROGRAMS

The Role of CARB in the AQMP Program

The California Air Resources Board was created by the California legislature for the purpose of providing..."a single State agency for administration, research, establishment of standards, and the coordination of air conservation activities carried on within the State." The CARB was given authority not only to control vehicular emissions within its jurisdiction, but also to establish air basins, set ambient air quality standards, conduct research programs, and to cooperate with the federal government. As indicated earlier, primary responsibility for stationary sources (including enforcement of State standards) remain with local and regional authorities. CARB, however, maintains a supervisory function which permits it to oversee standard setting and

enforcement operations of the local districts. Since the Board's responsibilities with regard to stationary sources are essentially oversight and do not increase unless local action is deficient or nonexistent, they will not be discussed further. The remainder of this section emphasizes the CARB's role with regard to implementing proposed AQMP measures in its primary areas of responsibility--vehicular emission control.

CARB, in conjunction with the Federal government and the automobile industry, have made significant steps in controlling mobile source emissions in California through existing emissions control programs. The Board, which assumed the duties of the Motor Vehicle Pollution Control Board upon its creation in 1967, has required several exhaust emissions and evaporative controls for motor vehicles in addition to the crankcase devices required by its predecessor. A number of the proposed measures discussed below are designed to ensure that these devices maintain their functions of mitigating pollutant emissions.

Regulatory Structure for Implementation of Proposed Mobile Source Controls

The four measures comprising the range of programs proposed for controlling mobile source emissions are:

1. More stringent light- and heavy-duty exhaust emission controls--approximately 50% reduction below 1977 prescribed levels.

2. Inspection/Maintenance program for light-duty vehicles.

3. Inspection/Maintenance program for other vehicles (including heavy-duty vehicles).

4. Heavy-duty gasoline exhaust retrofit.

1. More Stringent Auto Exhaust Emission Controls

Requiring more stringent automobile exhaust controls to reduce approximately 50% of prescribed levels is within the existing authority of the State Air Resources Board. Such requirements would assume the form of regulations, which would be determined and implemented by the Air Resources Board pursuant to State law.

2. Inspection/Maintenance Program for Light- and Heavy-Duty Vehicles

New legislation would be required to carry out inspection/maintenance programs in California. However, exactly which agency would implement this measure is unclear. The program could potentially be initiated by the Air Resources Board because of its air pollution control responsibilities, or the Bureau of Auto Repair (in the State Department of Consumer Affairs) which presently certifies mechanics throughout the State. Senate Bill 156 is currently before the California Assembly and proposes that the Air Resources Board be given authority to implement this particular program.

3. Inspection/Maintenance Program for Other Vehicles (Including Heavy-Duty Vehicles

The discussion under Number 2 above applies to this measure as well.

4. Heavy-Duty Gasoline Exhaust Retrofit

Implementing a retrofit program for heavy-duty gasoline-powered vehicles is not within the existing authority of the Air Resources Board. Therefore, implementation will require new State legislation. Such legislation might include provisions addressing the issue of how to discourage avoidance of the program through out-of-state registrations. Alternatively, the cooperation of states located adjacent to California might be requested in prohibiting California residents from seeking out-of-state registrations. Considering the large size of California and the relatively short-haul distance characteristics of this type of vehicle, out-of-state registrations may not be a large problem from a regulatory perspective.

Institutional and Financial Requirements

Institutional frameworks essentially already exist at the State level for carrying out all of the proposed mobile source control programs. The implementation of a more stringent automobile exhaust emission control regulation would extend existing emission control regulations for this source. Institutional arrangements presently used to implement the existing measure will serve adequately for the proposed one.

The specific set of institutional arrangements required to implement each of the proposed inspection/maintenance programs will depend on whether the State assumes direct responsibility for operating them or franchises them for private operation. If the programs were State-operated, the agency having implementation responsibility would undoubtedly require a substantial number of new personnel specifically trained to operate them. In addition, the necessary quisition of inspection and other analytical equipment will require that substantial capital investment be made to get the programs underway. A franchise system would also require a significant number of new personnel although less than would be required under the State-owned system. A substantial portion of the initial high capital costs would be avoided under the franchise system, since private industry would acquire it, but some such costs will be incurred to obtain equipment for testing and certifying private inspection equipment. High capital costs for site preparation is a possibility for an inspection/maintenance program applying to heavy-duty vehicles since the size of these vehicles may require special facilities to accommodate them. Because of their specialized characteristics and the magnitude of cost likely to be involved, the State may have to build them regardless of which system is adopted.

IMPLEMENTING TRANSPORTATION CONTROL PROGRAMS

The Role of MTC and other Transportation Agencies in the AQMP

While the Metropolitan Transportation Commission is the agency in the Bay Area responsible for specifying a regional Transportation Control Plan (TCP), implementation measures proposed in such a plan are the responsibility of a wide range of agencies at both local and regional levels. Most of these agencies have no regulatory responsibilities to each other or to the Commission, therefore institutional arrangements necessary to carry out a control strategy have been inadequate to date. The effectiveness of AQMP

proposed Transportation Control measures will depend as much upon cooperation between agencies as upon the individual measures themselves. Because of the diversity of programs and agencies required to implement them, a formal institutional structure with centralized regulatory authority may prove to be impractical. Therefore, an informal, well-integrated framework for interaction should be created, within which each program is carefully developed and closely coordinated with others to avoid counter-productive results.

<u>Institutional Structure for Implementation of Proposed Transportation Controls</u>

The following measures are proposed for implementation by 1985.

1. Toll increase applied on the Golden Gate and all Trans-Bay bridges to be phased with availability of sufficient transit capacity to accommodate increased ridership.

2. Regional parking strategy to be coordinated with para-transit and other transit-incentive programs.

3. Transit service increase of 20% by 1985.

4. Bus and Carpool Lane/Ramp Metering

    - Route 580 from Route 24 to Bay Bridge
    - Route 80 from Gilman to Bay Bridge
    - Route 101 from Bay Bridge to South San Francisco

5. Auto-Carpool Zone in the San Francisco Central Business District as specified in the San Francisco Parking Management Plan.

6. Bicycle systems.

1. <u>Toll Increase</u>

By 1985 a toll rate of $1.25 is proposed from passenger vehicles using Trans-Bay bridges during peak hours. The rate would drop to $1.00 for vehicles using the bridges during off-peak hours. Authority to implement this measure in the Bay Area presently exists within the Metropolitan Transportation Commission. However, such a schedule can only be adopted for implementation only after public hearings have been held and the California Toll Bridge Authority has approved the proposed schedule. The Bridge Authority is the agency responsible for actually collecting all bridge toll fees.

2. <u>Regional Parking Strategy</u>

The proposed parking control strategy consists of:

a) A parking tax applied during in-bound commute hours to all paid parking in the San Francisco, Oakland, San Jose, and Berkeley Central Business Districts.

b) Requiring major commercial facilities to levy a minimum charge for parking. The commercial operators would be permitted to keep half of this to cover their collection costs.

c) Allowing employers to cut back required parking in exchange for vanpooling or other transit incentive programs.

d) Requiring employers to implement preferential parking for carpools.

e) Encouraging Caltrans to continue its program of leasing lots for preferential carpool parking.

f) Encouraging cities to provide location and cost incentives for carpools in their municipal parking structures.

Authority to develop a tax structure reflecting measures a) and b) above currently exists within each of the specified municipalities. Reduced parking in exchange for para-transit and other transit programs would probably be most effectively accomplished through tax-incentive programs initiated by these same local governments. Memoranda of Understanding between MTC and Caltrans, MTC and the urban municipalities would serve adequately to encourage each to develop and continue carpool programs as specified in e) and f) above.

3. <u>Additional Transit Service</u>

Authority to accomplish this measure presently exists in local transit districts. The Metropolitan Transportation Commission has authority to financially subsidize increased transit service but only when funds become available from Federal grants, toll increases and other financing sources such as parking tax revenues from the proposed parking strategies specified above.

4. <u>Bus and Carpool Lanes/Ramp Metering</u>

The California Transportation Department (Caltrans) has authority at present, to implement bus and carpool lane/ramp metering programs for the specified locations. The details of how to implement this measure from a design standpoint would have to be explored further.

5. <u>Auto-Control Zone in the San Francisco Central Business District</u>

The concept of developing an auto-control zone in the San Francisco Central Business District has already been explored. Authority to implement such a measure presently exists in that city's government. The zone could be created by amending municipal code provisions pertaining to traffic management.

6. <u>Bicycle Systems</u>

Development of bicycle systems is currently within the existing authority of all Bay Area cities. By ordinance, municipalities can reserve portions of existing roadways within their jurisdictions maintained by them. They can also construct additional segments using funds from Federal, State and local sources.

Institutional and Financial Requirements

Institutional arrangements for implementing toll increases on Trans-Bay bridges are already in existence. The California Toll Bridge Authority has the authority to set and collect toll fees for use of bridges under its jurisdiction throughout the State. In the Bay Area, its power to set toll fee schedules exists but is subject to regulation by the Metropolitan Transportation Commission. For bridges located in its jurisdiction, the Commission may under conditions specified earlier, adopt a toll schedule in lieu of the brige authority's. The Authority may not approve a proposed Commission budget if it determines that such an action will: preclude the generation of sufficient revenues to properly operate or maintain the bridge, pay outstanding obligations, or adversely affect a State interest as determined by the State TransportationBoard. Implementation of a toll increase to the proposed levels will require the cooperation of all three of these agencies.

Implementation of a parking control strategy will require cooperation and close coordination between a broad range of public and private agencies and organizations. Potentially detrimental effects can result from an uncoordinated, self-serving effort on the part of individual local implementing participants. The planning and implementation of such a strategy should be coordinated by the Metropolitan Transportation Commission through Memoranda of Understanding with appropriate public agencies. The cooperation of respective private organizations in providing para-transit and other transit incentives would be secured through appropriate tax incentive programs undertaken by the particular city.

Recent studies by the Metropolitan Transportation Commission indicate that operating budget deficits will be a major factor determining transit services. While need for capital expenditures will certainly exist, additional transit service financial needs will have to be met in large measure, through increased operating subsidies.

Caltrans is responsible for implementing bus and carpool lane/ramp metering programs; however it is not authorized to implement projects solely for the improvement of air quality. It can build projects for transportation reasons although improved air quality may result from improved highway operation. This distinction is important for air quality maintenance planning purposes. The fact that Caltrans acts as an agent for several state transportation policy-making bodies indicates that it is not in a position to independently implement transportation control measures. Policy revisions of State highway construction needs would be required to give control measures requiring construction priority high enough to be funded ahead of other projects in the system. The initiation of such a priority would have to occur with the Metropolitan Transportation Commission's highway planning and programming function.

Development of an auto-control zone in San Francisco would be implemented through that city's regular traffic code enforcement procedures with no additional institutional arrangements required.

IMPLEMENTING LAND USE/DEVELOPMENT CONTROL PROGRAMS

The Role of Local Governments in AQMP Programs

At present, local governments comprising the nine counties of the Bay Area have no responsibilities for controlling air pollution. They are responsible however, for guiding location and development of new urban growth activities expected to contribute to the region's air quality problems. How these governments decide to manage new growth will be an important determinant of whether the region will be able to attain and/or maintain ambient air quality standards.

An institutional structure to implement proposed air quality-related regional development policies through land use control activities presently does not exist in the Bay Area. As with transportation controls a substantial impediment to implementing such measures is the institutional mechanism itself.

Regulatory Structure for Implementation of Proposed Land Use/Development Controls

Three basic objectives are sought from the broad range of land use policies and actions proposed for improving air quality. They are:

1. Reducing long-distance commuting by automobiles

2. Reducing the number of automobile trips and increasing transit usage

3. Increasing the efficiency of transportation systems to avoid congestion.

The State empowers its legal subdivisions--cities and counties, special districts and regional agencies--to perform four functions: regulation, acquisition, development and taxation. Each of these functions are needed in varying degrees, and affect the activities of numerous other entities, including individuals, corporations and other governmental agencies. Through deliberate planning and implementation, these powers can be used with positive effect to direct activities in accordance with regional air quality-related goals and objectives.

1. Reducing Long-Distance Auto Commuting

Eight policies and twenty-six actions support this objective and are effectively designed to reduce long-distance commuting across and within sub-regions of the Bay Area. The specified actions are within the existing authority of local governments, including special districts and county local agency formation commissions, as well as regional and State agencies. The actions are grouped within the framework of general policies. The structure of each policy suggests the institutional arrangements necessary to implement the actions. These arrangements are discussed in greater detail later.

Land management techniques currently available to local governments may be used to structure more compact development in the urbanizing areas of the region. The programming of urban service commitments (fiscally-related activities) can be performed in a manner supporting more compact

development. Regional and State agencies, working closely with local governments, have the capacity to perform the latter type of action. Local governments can also provide fiscal incentives within their respective jurisdictions to accomplish this type of development pattern.

2. Reducing Auto Trips and Increasing Transit Usage

Five policies and thirteen actions support this objective. Its purpose is twofold: to achieve both higher densities in new developments (thereby supporting transit development) and to attain a better mixture of residential, commercial, and industrial development types in all communities. The latter purpose is designed to bring trip-generating land uses closer together to reduce the overall length of trips by automobile throughout the region.

The actions specified are within the existing authority of local governments, regional and State agencies. Proposed regulatory actions to be implemented by local governments would directly affect density levels and types of development. Fiscally-related actions to be carried out by regional agencies, would augment local efforts by reviewing the locations of new development projects requiring public financing for supportiveness of other types of development and transit services.

3. Increase the Efficiency of Transportation Systems

Two policies support this objective and are designed to eliminate short-term inefficiencies in highway and transit system service caused by the uncoordinated timing of new development. The five proposed actions for implementing the policies are expected to achieve better coordination between the timing of new development and the transportation improvements required to support it. Local governments would enact land management measures related to sequencing new development and identifying its relationship to expected transportation improvements and/or commitments. Regional and State transportation agencies would program the funding of needed highway and transit improvements consistent with local sequence policies concerning land development.

Institutional and Financial Requirements

As indicated earlier, the structure of each policy defines the institutional arrangements necessary to implement it. For example, the policy of restricting the extension of new development to locations with existing or committed sewer and water service would require that county local agency formation commissions (LAFCOs), cities and counties closely coordinate several specified actions. One coordinated set of actions would be that LAFCOs would determine "Urban Service Areas" within prescribed city "spheres of influence" and cities and counties would enact non-urban zoning outside of the urban service areas. The policy of encouraging sewer and water development of unimproved land within or next to urban areas with such existing services would require coordination between local governments and regional agencies where State and Federal financing would be used in implementing such projects. A table depicting objectives, policies, and actions as well as specific agencies responsible for implementing them is included in an Appendix to this memo. The table also indicates the legal authority permitting these agencies to implement the actions and the funding mechanism to support the effort where available. The table is detailed but may not be exhaustive.

While the structure of government is determined in part by a set of legislative rules, these formal guidelines do not necessarily constitute the operational rules which define the specific organizational choices available. The task of adjusting local needs to regional air quality objectives will undoubtedly require some bargaining and accommodation, particularly with regard to implementing the proposed actions. The use of memoranda of understanding, resolutions and joint exercise of powers agreements to accomplish of the objectives should be explored in greater detail.

Financial requirements for public agencies implementing the proposed policies and actions are primarily administrative in nature. Since most of the actions propose using existing regulations and practices in new ways over long periods of time, actual requirements for financing their administration may be modest over existing annual requirements. The requirements of particular agencies in meeting the costs imposed by particular measures will be defined by the informal bargaining and accommodation process alluded to earlier.

SUMMARY

It should be reemphasized that the institutional structures needed to implement the majority of the proposed AQMP programs and actions are in existence. Some new legislation will be required to implement certain vehicle emissions control programs. However, the overall need for new legislation is minimal. Greater emphasis will be necessary on structuring the institutional arrangements for implementing transportation and land use programs to achieve ambient air quality standards. A delicate balance between programs in each of the specified control categories must be achieved if attainment of ambient air quality standards is to be approached and undue economic hardship on the region avoided. The complexity of the actions comprising the total strategy requires at a minimum, commitment by all levels of government to undertake good faith efforts to implement the Air Quality Maintenance Plan as "expeditiously as practicable" and to make steady progress toward that goal until it is achieved.

APPENDIX

AQMP CONTROL MEASURES FOR LAND DEVELOPMENT

		Responsible Agency	Legal Authority*	Funding Mechanism**
OBJECTIVE A-1:	REDUCE LONG-DISTANCE AUTO COMMUTING (BETWEEN SUB-REGIONAL AREAS) Reduce current long-distance auto commuting and discourage urban development regionwide that results in more auto commuters in more urban areas. Induce more compact urban development in all urbanizing areas of the region through land management techniques. Recognize urban service commitments as incentives for compact development and disincentives for scattered development.			
Policy 1:	Restrict the extension of new development to those locations with existing or committed sewer and water service.			
Action	a) Complete LAFCOs' regionwide adoption of city and special district spheres of influence.	LAFCOs	§54774, 54774.1, 54790	
Action	b) Adopt "Urban Service Area" concept for defining city and special district spheres of influence in terms of service commitments and projected land needs. (5 year, 10 year, 20 year estimates).	LAFCOs	§54774, 54774.1, 54790	
Action	c) Carry out policy on formation and annexation of cities and special districts consistent with (b) above.	LAFCOs	§54790(a)	
Action	d) Enact non-urban zoning (Agricultural zoning "Holding Zones") outside urban service areas.	Cities, Counties	Cal. Const. Art. XI, §7 §65850(a)	
Action	e) Enact temporary moratoria on rezoning and subdivision outside of urban service areas.[1]	Cities, Counties	§65858	
Policy 2:	Restrict development of locations outside urban service areas which constitute critical areas of environmental concern (environmental resources, hazards, or amenities).			
Action:	a) Establish programs of public land acquisition, purchase/transfer of development rights, purchase/leaseback, etc.	Cities	§6950, §6954, §50575, §50628	General Fund, Bonds
		Counties	§6950, §6954, §50575, §50628	G/F, Bonds
		LAFCOs[2]	§54774.5, §54790.2	
		Special Districts	§54340, §54309.1	G/F, Bonds
		BCDC[3]	§66606.5	
		State Coastal Conservancy[4]	Public Resources Code §31105	State Legislative Appropriation

*All citations refer to California Government Code unless otherwise noted.

		Responsible Agency	Legal Authority*	Funding Mechanism**
Action	b) Initiate, continue or expand programs under California Land Conservation Act (Williamson Act), the Open Space Easement Act of 1974, and the Z'Berg-Warren-Keene-Collier Forest Taxation Reform Act of 1976.	Cities, Counties	§51200 Et. Seq., §51070-51146 §5110-51146	
Action	c) Enact agricultural zoning and large lot rural residential zoning (generally one dwelling unit/40 acre minimum lot size) where appropriate, to restrict development of critical environmental areas.	Cities, Counties	Cal. Const. Art. XI, §7 §65850 (a) (c)	
Policy 3:	Encourage development of unimproved land within or next to urban areas with existing or committed urban services, relating this to sewer and water service capacities.			
Action	a) Establish "early warning" inter-agency information exchange and project reviews of sewer/water projects via A-95 review and clean water grant plan EIR review.	ABAG	Title 42 USC §5304 (e)	EPA Clean Water Grants
Action	b) Expedite city, county, LAFCO or ABAG project review where needed information on service capacities have been provided by a) above.	Cities Counties LAFCO, ABAG		
Action	c) Initiate rezoning and permit preference procedures in locations with excess capacity in sewer/water/transportation service.	Cities, Counties	Cal. Const. Art. XI, §7 §65850 (a)	
Policy 4:	Expedite completion of needed sewer or water service improvements in all suitable locations within or contiguous to existing urban areas.			
Action	a) Expand and expedite general purpose agency review of single purpose service agencies' Capital Improvement Programs to coordinate service schedules.	ABAG, LAFCOs	Joint Powers Agreement §54774 Et. Seq.	
	b) Use A-95 review and funding allocation procedures to expedite State/Federal financial assistance to agencies lacking service capacity in areas where other services already are capable of accommodating additional development.	ABAG MTC	Title 42 USC §5304(c) §66520	
Policy 5:	Encourage "infill" development of bypassed vacant land within existing urbanized areas.			
Action	a) Undertake planning studies to inventory bypassed land; identify development problems, and resolve questions of best potential use.	Cities, Counties, ABAG, OPR	§65100 Et. Seq. Joint Powers Agreement §13990.6	Redevelopment tax increment financing.

		Responsible Agency	Legal Authority	Funding Mechanism**
Action	b) Make necessary changes in zoning and permit procedures to facilitate the development of bypassed parcels affected by special conditions.	Cities, Counties	Cal. Const. Art. XI, §7 §65850	
Action	c) Design sewer/water/transportation systems to improve accessibility and serviceability of bypassed vacant land.	Cities, Counties	Cal. Const. Art. XI, §9	
Action	d) Permit the transfer of development rights from undeveloped fringe areas to vacant land within existing urbanized areas.	Cities, Counties	Cal. Const. Art. XI, §7	
Policy 6:	Increase housing and job opportunities in existing urbanized areas. Encourage public and private rebuilding into compatibly mixed land uses at higher densities.			
Action	a) Initiate and/or expand housing conservation programs and housing replacement programs in the already urbanized areas.	Cities, Counties	Health & Safety Code §37910, §37964	Bonds
Action	b) Initiate and/or expand commercial and industrial development and redevelopment programs in the already urbanized areas.	Cities, Counties	Health & Safety Code §33000 Et. Seq.	Bonds
Action	c) Initiate and/or expand capital improvement and maintenance programs, and community facilities and services which can serve as direct incentives to redevelopment in the urbanized areas. Emphasize sewer and water facilities and intensive transit service improvements. Also include educational and cultural facilities and public safety services.	Cities, Counties	Cal. Const. Art. XI	G/F

		Responsible Agency	Legal Authority*	Funding Mechanism**
OBJECTIVE A-2:	REDUCE LONG-DISTANCE AUTO COMMUTING (WITHIN SUB-REGIONS) Slow the trend toward increased longer distance auto commuting to south bay locations resulting from: --a continuing imbalance between south bay regional growth trends and under-utilized service capacities in the north bay. --a continuing pattern of unbalanced job/housing growth in the south bay. Induce a larger share of new regional job and housing development into north bay locations and establish matching disincentives to development in the south bay.			
Policy 7:	Encourage urban development in north bay jurisdictions where urban service capacity exists or can be committed by joint local/regional/state action			
Action	a) Conduct A-95 plan and project reviews to encourage development in north bay jurisdictions.	ABAG MTC	Title 42 USC §5304 (e) §66520	
	b) Support State/Federal funding allocations for services and facilities which would offer incentives to development in these jurisdictions.	ABAG MTC	Same as a) above.	
Policy 8:	Restrict the intensification of development in south bay jurisdictions to a population level or employment level consistent with existing or committed urban service capacities. Emphasis would be on sewer and water capacities but also include other urban services such as schools, fire protection, police protection, etc.			
Action	a) Enact temporary moratoria on rezoning and subdivisions.[5]	Cities, Counties	§65858	
	b) Enact temporary moratoria on building permit and sewer/water hookups.[6]		§65858 Cal. Const. Art. IV, §25 Cal. Elections Code §4000-4021[7]	
Action	c) Limit State/Federal funding of south bay urban service improvements to current design and funding levels.	ABAG MTC	Title 42 USC §5304 (e) §66520	

		Responsible Agency	Legal Authority*	Funding Mechansim**
OBJECTIVE 8:	REDUCE THE NUMBER OF AUTO TRIPS AND INCREASE TRANSIT USAGE Reverse the trend of more auto trips and less transit usage. Use land management techniques and service commitments as incentives for higher density development. In all new land development regionwide: --Promote high density development that is supportive of transit usage. --Discourage low density development that promotes automobile dependency.			
Policy 9:	Encourage higher density development in urban areas where existing or committed urban service capacities, including rail transit, can support higher densities.			
Action	a) In urban areas with adequate sewer/water/rail transit capacities, rezone appropriate locations to permit higher densities.	Cities, Counties	Cal. Const. Art. XI §7	
	b) Enact Planned Unit Development (PUD) and/or "Cluster Zoning" Ordinances to foster higher densities on appropriate sites.	Cities, Counties	Cal. Const. Art. XI. §7 §65850	
	c) Review general plans and development projects in urban areas in keeping with criteria on service capacities.	ABAG MTC	Title 42 USC §5304(c) §66520	
Policy 10:	Discourage development of land within urban service areas where soil, slope, or other conditions can support only low-density development.			
Action	a) Establish programs of public land acquisition purchase/transfer of development rights, purchase/leaseback, etc.	Cities	§6950, §6954, §50575, §50628	G/F, Bonds
		Counties	§6950, §6954, §50575, §50628	G/F, Bonds
		LAFCOs	§54774.5, §54790.2	
		Special Districts	§54340, §54309.1	G/F, Bonds
		BCDC	§66606.5	
		State Coastal Conservancy	Public Resources Code §31105	State Legislative Appropriation
Action	b) Enact Planned Unit Development (PUD) and/or "Cluster Zoning" Ordinances to foster higher densities on appropriate sites.	Cities Counties	Cal. Const. Art. XI, §7 §65850	

			Responsible Agency	Legal Authority*	Funding Mechanism**
Action	c)	Deny primary urban services to these low-density locations through exclusion from capital improvement programs, exclusion in system design, enactment of hook-up moratoria, etc.	Cities	Cal. Const. Art. XI, §7, §9	
Policy 11:		Defer for short periods of time (2 years or less) auto-dependent land development which would preclude pending transit improvements.			
Action	a)	Enact temporary moratoria on rezoning and subdivisions.[8]	Cities	§65858	
OBJECTIVE B-2:		REVERSE THE TREND OF MORE AUTO USAGE			
		Use land management techniques to achieve a better balance of housing, commerce and industry in each urban area.			
Policy 12:		Encourage a mixture of residential/commercial/industrial development types in all communities.			
Action	a)	Revise zoning ordinances to allow mixtures of land uses with adequate design or performance standards.	Cities, Counties	Cal Const. Art. XI, §7	
	b)	Expand application of "Planned Unit Development Zones" or "Floating Zones."	Cities, Counties	Same as a) above	
Action	c)	Expand use of Conditional Use Permits	Cities, Counties	Cal. Const. Art. XI, §7	
Policy 13:		Discourage new large-scale land development projects that are exclusively commercial, industrial or residential.			
Action	a)	Deny incorporation of, or continued annexation of "single-use" large-scale land development projects.	LAFCOs	§54790(a)	
Action	b)	Deny regional transportation system access or extension to "single-use" large-scale land development projects.	MTC	§66518, §66520, §66521	

		Responsible Agency	Legal Authority*	Funding Mechanism**
OBJECTIVE C:	INCREASE THE EFFICIENCY OF TRANSPORTATION SYSTEMS TO AVOID CONGESTION			
	Prevent the added pollution caused by short-term inefficiencies of highways and transit systems service to new land development. Stage land development plans with the funding schedules of needed highway/transit improvements to:			
	--Minimize congestion on highways and transit systems caused by premature land development			
	--Allocate the limited resources for highway transit improvements to the place and time they can best contribute to minimizing air pollution			
Policy 14:	Integrate the timing of highway and transit system improvements with local policies on sequence of land development.			
Action	a) Enact Development Sequence Zoning (aka "Timing Zoning", "Phased Zoning").	Cities, Counties	Cal. Const. Art. XI, §7	
	b) Recognize staged land development plans in Planning and Programming of highway and transit improvements.	Cities, Counties MTC	Same as a) above. §66518, §66520, §66521	
Policy 15:	Program funding of needed highway and transit improvements consistent with development sequence zoning.			
Action	a) Adopt highway capital improvement programs consistent with city/county approvals of sequence zoning.	Cities, Counties Caltrans	Cal Const. Art. XI, §7 §14030, §14040.2	
Action	b) Adopt transit capital improvement programs and operating budgets consistent with city/county approvals of land development projects and sequence zoning.	Cities, Counties Caltrans, MTC	Cal. Const. Art. XI, §7 §14030, §14040.2 §66518, §66520, §66521	
Action	c) Enact performance standard zoning with criteria for assessment of impact on transit service commitments and committed highway improvements.	Cities, Counties	Cal. Const. Art. XI, §7 §65850	

FOOTNOTES

1. California Government Code 65858 permits a general law city or county to adopt the type of moratorium proposed in policy 1, action e, only as an urgency measure when the city or county is considering, studying, or intends to study within a reasonable time, a contemplated zoning proposal with which a proposed rezoning or subdivision would conflict. The maximum duration of such a "moratorium" is two years.

2. While LAFCOs are not empowered to acquire real property (California Government Code 54790), they do have certain responsibilities pertinent to the preservation of open space lands. See California Government Code 54774.5 - Urban development patterns; preservation of open-space lands; and 54790.2 - Conversion of open-space lands to other uses; policies and priorities.

3. BCDC is likewise not empowered to acquire real property, California Government Code 66630-66657, but it also has responsibilities related to open space. (See California Government Code 66606.5 - Findings and declarations as to substantial public investment and reports on financing required to acquire public property.)

4. Neither the California Coastal Zone Conservation Commission nor any of the regional commissions is empowered to acquire real property (California Public Resources Code 30330-30342). However, the State Coastal Conservancy is entitled to acquire interests in land using funds appropriated by the State Legislature (California Public Resources Code 31105).

5. See Note 1.

6. See Note 1.

7. Article II, §11 of the California Constitution and Elections Code §4000-4021 provide that initiative powers may be exercised by the electors of cities and counties. This power was recently used by the electors of the City of Livermore to enact a building permit moratorium. See Associated Home Builders of the Greater East Bay v. City of Livermore, 18 C.3d 582 (1977), wherein the California Supreme Court sustained this use of the initiative power.

8. See Note 1.

AQMP Tech Memo 17
L. Robinson

September, 1977

BASELINE LIRAQ AIR QUALITY PROJECTIONS

INTRODUCTION

This technical memorandum documents baseline air quality calculations of ozone made with the Livermore Regional Air Quality Model LIRAQ. Results are presented for 1975 baseyear emissions and 1985 and 2000 future-year emissions expected under "normal growth."

Operational Features of LIRAQ

LIRAQ is an interrelated set of computer codes and subroutines which acts upon emissions as inputs to produce concentrations as outputs. Specifically the photochemical version of LIRAQ* transforms emission and meteorological inputs into concentration outputs. These simulated concentrations are conveniently printed by LIRAQ as a series of maps of pollutant concentrations. These diagrams look much like conventional weather maps. LIRAQ draws a sequence of such concentration maps for each pollutant in the emission inputs and for certain pollutants not input as emissions, but calculated therefrom - ozone for example. Sequence timing is such that a set of pollutant concentration maps is output for each hour of a selected case study day.

The ozone maps are the LIRAQ results of greatest interest in the AQMP process. This is because the maps represent regionwide expectations - present and future - for the pollutant which has historically been of greatest concern in the San Francisco Bay Area - photochemical oxidant. In later sections baseline results are presented as a series of ozone maps and tabulations of regionwide high-hour ozone derived from these maps. Baseline results are also presented as tabulations of high-hour ozone at representative locations in the region.

Technical Overview of LIRAQ

LIRAQ is a dynamic, grid-based, multi-species, deterministic photochemical model. For a given pollutant species, LIRAQ calculates a sequence of concentration fields by repeatedly solving the Eulerian form of the conservation of mass equation in a

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*There are really two LIRAQ models, LIRAQ-1 and LIRAQ-2. LIRAQ-2 utilizes photochemical reactions in its calculations while LIRAQ-1 does not, but has certain other advantages over LIRAQ-2. "LIRAQ" as used hereafter refers to the latest version of LIRAQ-2. This is the so-called "new chemistry" version that incorporates sulfur reactions in the calculations. All baseline results in this memo were obtained by running LIRAQ-2 with the new chemistry.

sequence of variable time-steps short enough to insure a stable computation. For a given time-step, concentrations are calculated everywhere across the spatial grid; time is then incremented and a new gridwide solution obtained, etc. Inter-species photochemical reactions occur which cause the model numerically to create ozone and other secondary pollutant concentrations.

The Lawrence Livermore Laboratory has documented in detail the technical aspects of the LIRAQ model in Volumes I and II of the report titled "Development of an Air Pollution Model for the San Francisco Bay Area." In addition, AQMP Issue Paper Number 1* discusses the general problem of selection of an appropriate model, describes various types of air quality models, inventories and categorizes models, and outlines the advantages of LIRAQ to the Bay Area problem.

PREPARATION OF LIRAQ INPUTS

LIRAQ requires emission inputs which vary in time because it is a dynamic model, which vary in space because it is a grid-based model, and which vary in variety because it is a multi-species model. With respect to space and time variation, the same comments apply to the meteorological inputs.

These LIRAQ characteristics thus induce a requirement for considerable space and time detail in the two main LIRAQ inputs - emissions and meteorology. To achieve the needed detail in the emissions inventory, the file is broken down into emissions of six species, alkenes, alkanes, aldehydes, nitric oxide, sulfur dioxide, and carbon monoxide**. For each pollutant listed, emissions are determined in grams per second within every 5-kilometer grid square*** in the nine-county AQMP study region. Within each 5-kilometer grid square and for each species, the emission rate in grams per second is redetermined for each hour of the selected quarter of the year and day of the week. Similarly, the meteorological files contain adjusted wind and inversion height data which varies across each 5-kilometer grid square*** in the region and which also varies with time.

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*AQMP Issue Paper 1, "Air Quality Modeling for the San Francisco Bay Region."

**Emissions of particulate matter are also included in the inventory but are not used in either LIRAQ-1 or LIRAQ-2 computations.

***Emission and meteorological data sets were determined for 1-kilometer and 2-kilometer grid square sizes also. LIRAQ-2 mainly uses the 5-kilometer files because of computer memory restrictions on the complex photochemical calculations. LIRAQ-1 does no photochemical computations and so can more conveniently use the more detailed 1- and 2-kilometer files, mainly for CO simulations.

Preparation of the Emission Files

To construct a single LIRAQ emission inventory is a time-consuming task. Three inventories were prepared for the baseline runs; one for baseyear conditions in 1975 and two for future-year conditions expected in 1985 and 2000 under normal growth assumptions. These assumptions refer to the base-case 1 or "hi-growth" population projections of Series III.

References pertaining to the preparation of the baseline emission files are found in several technical memos and reports. Technical Memorandum 1* describes base-year selection and technical assumptions. Technical Memorandum 2* describes the projection methodologies, technical assumptions, and overall system components. Technical Memorandum 12* expands on methodologies used in the preparation of the baseline motor vehicle component emissions and gives results. For stationary sources, the BAAPCD assembled an extensive report titled "Source Category Methodologies." It documents baseline stationary emissions for point and "area" sources**, including locations, rates, projections, and methodologies. Technical Memorandum Number 21* describes how emissions from stationary sources identified only as to source origin category and not location were disaggregated spatially in conformity with ABAG Series III population and employment projections.

QSOR is the file name of the emissions data set which is actually input to LIRAQ after having been prepared in accordance with the cited documentation. A QSOR file is the sum of four standard intermediate files - named PNT, POP, AIR, and CAR - each of which has itself already been spatially and temporally detailed in 5-kilometer grid squares, hour-by-hour.

CAR is the file name of the vehicle emissions data set prepared as described in Technical Memorandum 12. AIR is the file name for emissions from aircraft operations at 36 different airports in the region. PNT is the file name for stationary source emissions from point sources which are identifiable as to location (all 100 tons/year sources and any lesser sources, when known). Any such point source emission is documented, located and given a temporal distribution in the BAAPCD report. For example, PNT is constructed from about 700 entries in 1975. Each entry gives an annual average emission rate for one of the following pollutants - organics, NO_x as NO_2, SO_2, CO and particulate matter. In addition, each entry gives the location of the emission in UTM coordinates and the percent variation in the annual average emission rate by quarter of the year and days of operation during the week. Hours of operation during a working day are also given. Thus the hour-by-hour emission rates in PNT are obtained by adjusting an entry's annual average rate to quarter of the year, day of the week and hours of the day operated.

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*Technical Memo 1 is titled "Base Year Selection and Technical Assumptions."
Technical Memo 2 is titled "Projections/Forecasting: System Description and Technical Assumptions." It includes an Appendix.
Technical Memo 12 is titled "Baseline Motor Vehicle Emission Inventory: Methodology and Results."
Technical Memo 21 is titled "Geographical Distribution of Emissions from Non-Major Point (Area) Sources "

**Used here to mean sources identifiable only by source origin category and not location.

This is done for every point source within a given 5-kilometer grid square and the results summed over all "within the grid square" sources for the same hour. POP is the file name for stationary source emissions identifiable only as to source origin category and not location in the BAAPCD report. POP is obtained by disaggregating such emissions temporally according to the report recommendations and spatially according to Technical Memorandum 21.

Table 1 gives total emissions in tons/day due to summing over all hours and grid-squares for these four detailed files. In addition a grand total line is shown which represents the total emissions in the QSOR file used by LIRAQ. These totals conveniently summarize the emissions which LIRAQ actually processed to produce ozone concentrations. They serve as a check on and give some insight into the LIRAQ results. If compared with the totals given in Technical Memorandum 11*, small but persistent differences will be seen. Differences are from 2% to 5% for organics and NO_x as NO_2 and as high as 11% for SO_2 in 1985. These differences are partially due to the need to adjust annual average emissions to hourly rates according to quarter of the year, days of operation during the week, and hours of operation during the day for the point sources. The difference is largest for SO_2 and SO2 is the pollutant for which such an adjustment should have the largest effect because it is point source dominated - in 1985 greater than 85% of SO_2 emissions were from point sources. Other technical factors also affect comparisons in Table 1 with Technical Memo 11, such as maximum grid size definitions for the QSOR files.

Meteorological Inputs and Prototype Days

That emissions inventory preparation for LIRAQ is a complex task is evidenced by the amount of documentation cited as well as the time involved, more than a year to construct the files. Of Almost equal complexity is the selection and analysis of an appropriate day from the past when meteorological conditions caused the development of moderate or high oxidant readings and the incorporation of these weather conditions into a LIRAQ compatible input file - called a QTRANS file. Fortunately due to earlier work, the LIRAQ library of QTRANS files already contained three such days**, two of which were used for baseline studies. These days were July 26, 1973 and August 20, 1973. The July 26, 1973 day was typical of days with meteorology conducive to oxidant episodes in the Livermore Valley. A high hour reading of .18 ppm was recorded at Livermore on this day. The August 20, 1973 day was typical of days with meteorology conducive to only light or moderate development of oxidant. A high hour reading of .08 ppm was recorded at Concord on this day.

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*AQMP Tech Memo 11, "Present and Projected Air Pollutant Emissions in the San Francisco Bay Region."

**Two more days will be added in the near future - July 24, 1974 and September 13, 1971. The former day had an observed high hour oxidant of .20 ppm and the latter had an observed high hour oxidant of .29 ppm, the record for the decade of the seventies. Work has begun on a third day, July 25, 1975, which is representative of high oxidant development in the north counties.

TABLE 1

Baseline Emission Totals

Oxides of Nitrogen as Nitric Oxide, Tons/Day

Source of Emissions	1975	1985	2000
Point (PNT)	125.32	192.99	141.07
Area (POP)	65.88	105.03	131.05
Airports (AIR)	8.61	12.52	20.93
Stationary Total	199.81	310.54	293.01
Mobile (CAR)	254.41	162.42	182.65
GRAND TOTAL (QSOR)	454.22	472.96	475.66

Oxides of Nitrogen as Nitrogen Dioxide, Tons/Day

Source of Emissions	1975	1985	2000
Point (PNT)	192.16	295.92	216.31
Area (POP)	101.02	161.05	200.94
Airports (AIR)	13.20	19.20	32.09
Stationary Total	306.38	476.17	449.34
Mobile (CAR)	390.09	249.05	280.07
GRAND TOTAL (QSOR)	696.47	725.22	729.41

Alkenes, Tons/Day

Source of Emissions	1975	1985	2000
Point (PNT)	25.92	29.11	36.02
Area (POP)	80.68	83.45	111.30
Airports (AIR)	7.07	7.10	9.98
Stationary Total	113.67	119.66	157.30
Mobile (CAR)	103.60	46.54	58.71
GRAND TOTAL (QSOR)	217.27	166.20	216.01

TABLE 1
(Continued)

Baseline Emission Totals

Alkanes, Tons/Day

Source of Emissions	1975	1985	2000
Point (PNT)	98.16	107.98	133.58
Area (POP)	299.30	309.50	412.70
Airport (AIR)	12.60	12.66	17.81
Stationary Total	408.06	430.14	564.09
Mobile (CAR)	333.90	150.04	189.30
GRAND TOTAL (QSOR)	741.96	580.18	753.39

Aldehydes, Tons/Day

Source of Emissions	1975	1985	2000
Point (PNT)	4.63	5.20	6.43
Area (POP)	14.41	14.90	19.87
Airports (AIR)	2.85	2.86	4.02
Stationary Total	21.89	22.96	30.32
Mobile (CAR)	29.61	13.22	16.98
GRAND TOTAL (QSOR)	51.50	36.18	47.30
GRAND TOTAL ALL ORGANICS (QSOR)	1,010.50	782.20	1,016.70

Oxides of Sulfur as Sulfur Dioxide, Tons/Day

Source of Emissions	1975	1985	2000
Point (PNT)	197.67	424.73	347.01
Area (POP)	12.25	32.86	50.31
Airports (AIR)	1.28	1.51	2.46
Stationary Total	211.20	459.10	399.78
Mobile (CAR)	18.89	24.80	33.58
GRAND TOTAL (QSOR)	230.09	483.90	433.36

TABLE 1
(Continued)

Baseline Emission Totals

Carbon Monoxide, Tons/Day

Source of Emissions	1978	1985	2000
Point (PNT)	80.40	82.91	98.61
Area (POP)	336.20	388.30	464.30
Airports (AIR)	54.14	67.97	106.30
Stationary Total	470.74	539.18	669.21
Mobile (CAR)	3,808.00	3,428.00	4,941.00
GRAND TOTAL (QSOR)	4,278.74	3,967.18	5,610.21

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Several months of effort go into the development of any prototype day for the LIRAQ library because of the data collection and computer processing task involved. Surface wind observations must be collected and put on the computer for as many stations as possible. In addition three-hourly inversion base height maps must be prepared for the entire region and put into computer readable format. The wind and inversion base height data is then processed by a special program called MASCON to produce a mass-consistent set of fluxes for LIRAQ, the QTRANS file. Trained meteorologists usually have to repeat this processing several times before they are satisfied with the final result, because of specific data gaps in the space-time variation of the inversion base height. On some occasions this process has yielded QTRANS files which produced unacceptable LIRAQ test results*. Thus, in spite of the meteorologist's expertise in interpolating missing observations, a lack of adequate inversion base height can be an obstacle to successful incorporation of a new prototype day into the LIRAQ Library.

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*The test is to use LIRAQ-1 and 1-kilometer emissions detail to simulate CO. The LIRAQ-1 model has the most accurate advection algorithm, no photochemistry, and the most detailed emission inventory. If the resulting CO maps are not representative, the QTRANS files are most likely at fault.

BASELINE RESULTS

Figures 1a through 1e display the set of baseline maps for ozone produced by LIRAQ. These cover the hours from 1000 PST through 1900 PST and the years 1975, 1985 and 2000. Regionwide high-hours have been derived from these maps. Results for regionwide high hours and station high hours* are presented and discussed in the final section of this memo. First however, some comments are made on the verification of LIRAQ output.

Verification Analysis

Extensive results were given on the verification of the "old chemistry" version of LIRAQ in the two volumes of the LLL publication previously cited. The AQMP modeling committee recommended that the verification be repeated because of the decision to make the baseline runs on the new chemistry version of LIRAQ.

VERF is the name of a special program that can be used to compare the output of a LIRAQ simulation with observations. To make such comparisons again, the 1975 emissions files were taken as a reasonable approximation to actual emissions on two days in 1973: July 26 when oxidant reached heavy levels and August 20 when oxidant reached light to moderate levels. LIRAQ runs were made on these two days using the same 1975 QSOR emission file as input to both runs. The LIRAQ output (on magnetic tape) was then run through program VERF to produce the observation versus simulation statistics given in Table 2. A quite basic verification criterion is that LIRAQ reproduce heavy levels of ozone on a day when the meteorology actually caused heavy levels and reproduce light to moderate levels - the emissions being constant in the simulation and very nearly constant in actual fact. Examination of Table 2 shows that LIRAQ passed this fundamental test in good order. (See the observed versus predicted high-hour ozone for individual stations.) Table 2 also includes the root mean square errors between observed and predicted values and overall correlation statistics.

Baseline Calculations for 1975, 1985 and 2000

Table 3 shows baseline calculations complete for all three years for the July 26, 1973 prototype day. The observed high-oxidant for this day was .18 ppm at Livermore. This high hour value reflects the emissions that occurred in 1973. Based on 1975 emissions, the model simulated .13 ppm at Livermore and a regionwide high hour of .17 ppm about 6 miles (9.5 kilometers) SSE of Livermore. (See Figure 1b and the column labeled 1975 in Table 3.) Table 3 also displays the effect of normal future changes in 1985 and 2000 emissions on the development of oxidant. It shows that the regionwide high hour is expected to go from .17 ppm in 1975 down to .13 ppm in 1985, then back up to .17 ppm in the year 2000, given the assumption of normal growth in the emissions. The changes in normal growth emission totals are given in Table 1. The most important emission changes in Table 1 are those of the three organic classes - alkenes, alkanes, and aldehydes - and nitric oxide. Table 1 shows that the model is making less oxidant

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*Station high-hour ozone is derived from another set of LIRAQ graphical outputs. These are plots at individual stations of ozone as a function of hour of the day. No examples of these "time series" plots have been included in this Technical Memo.

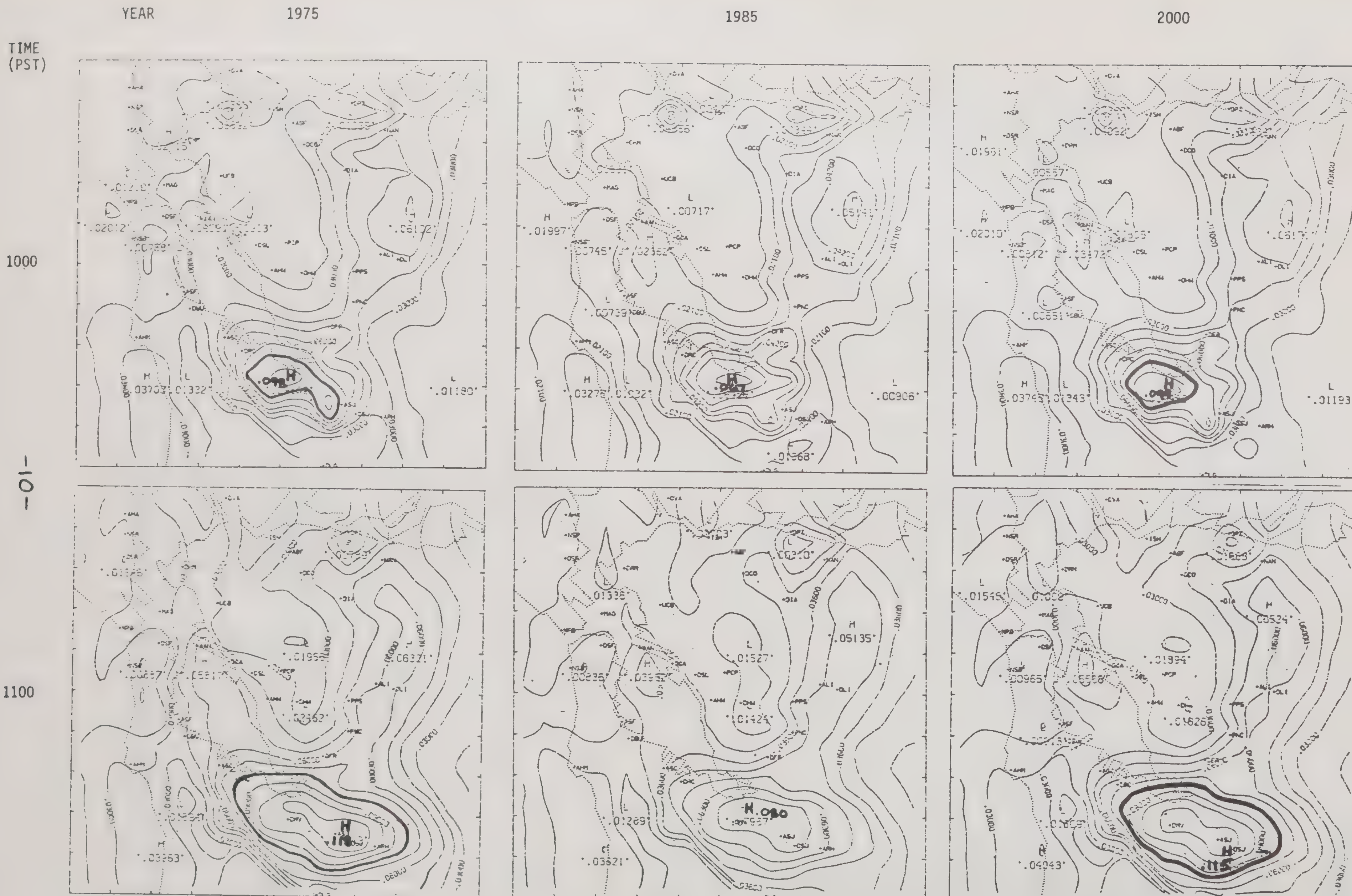


FIGURE 1A

BASELINE OZONE COUTOUR MAPS, JULY 26, 1973 METEOROLOGY, NEW CHEMISTRY,

WITH 0.08 PPM CONTOUR ENHANCED TO SHOW AREA EXCEEDING FEDERAL STANDARD.

YEAR 1975 1985

TIME (PST)

1200

1300

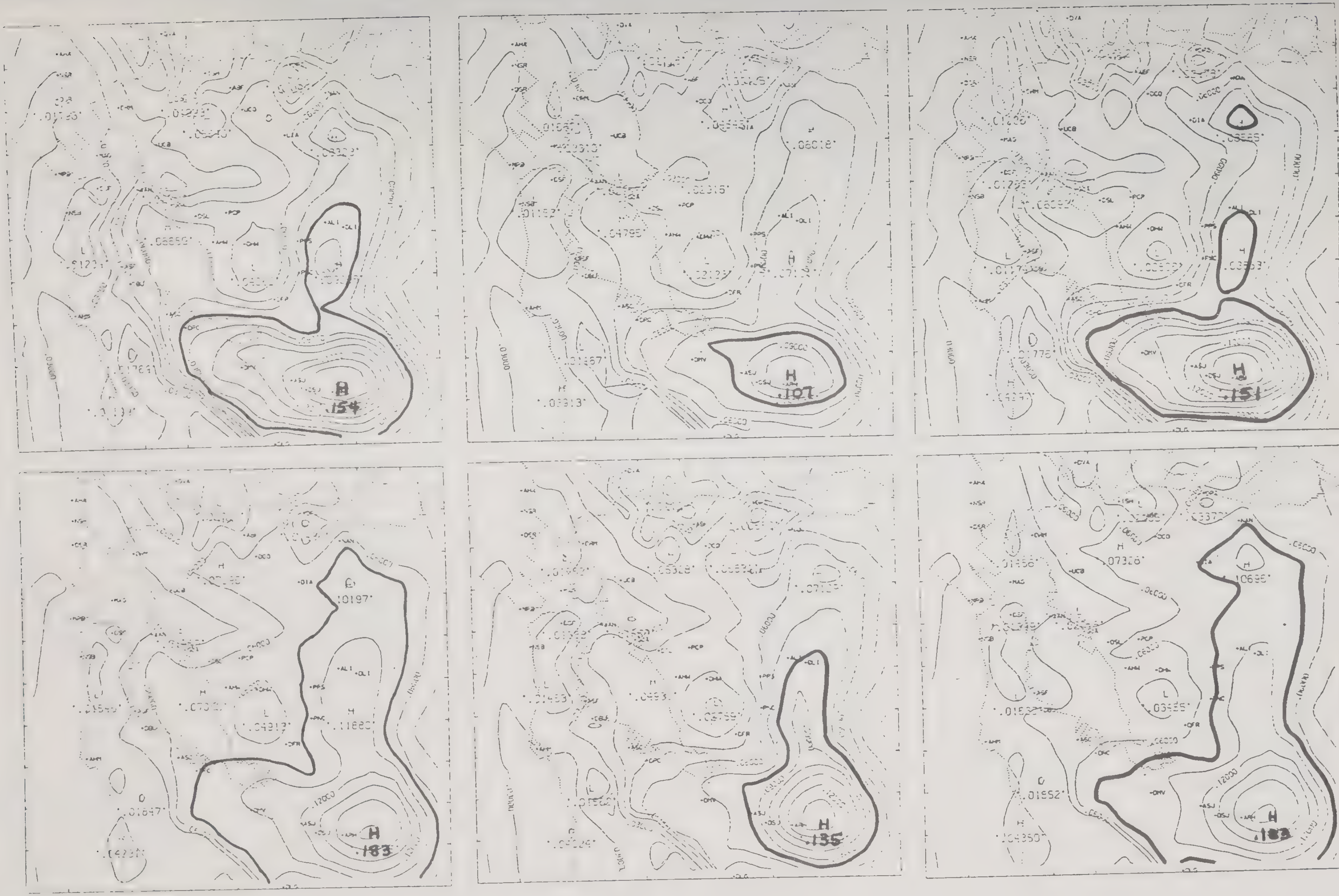


FIGURE 1B

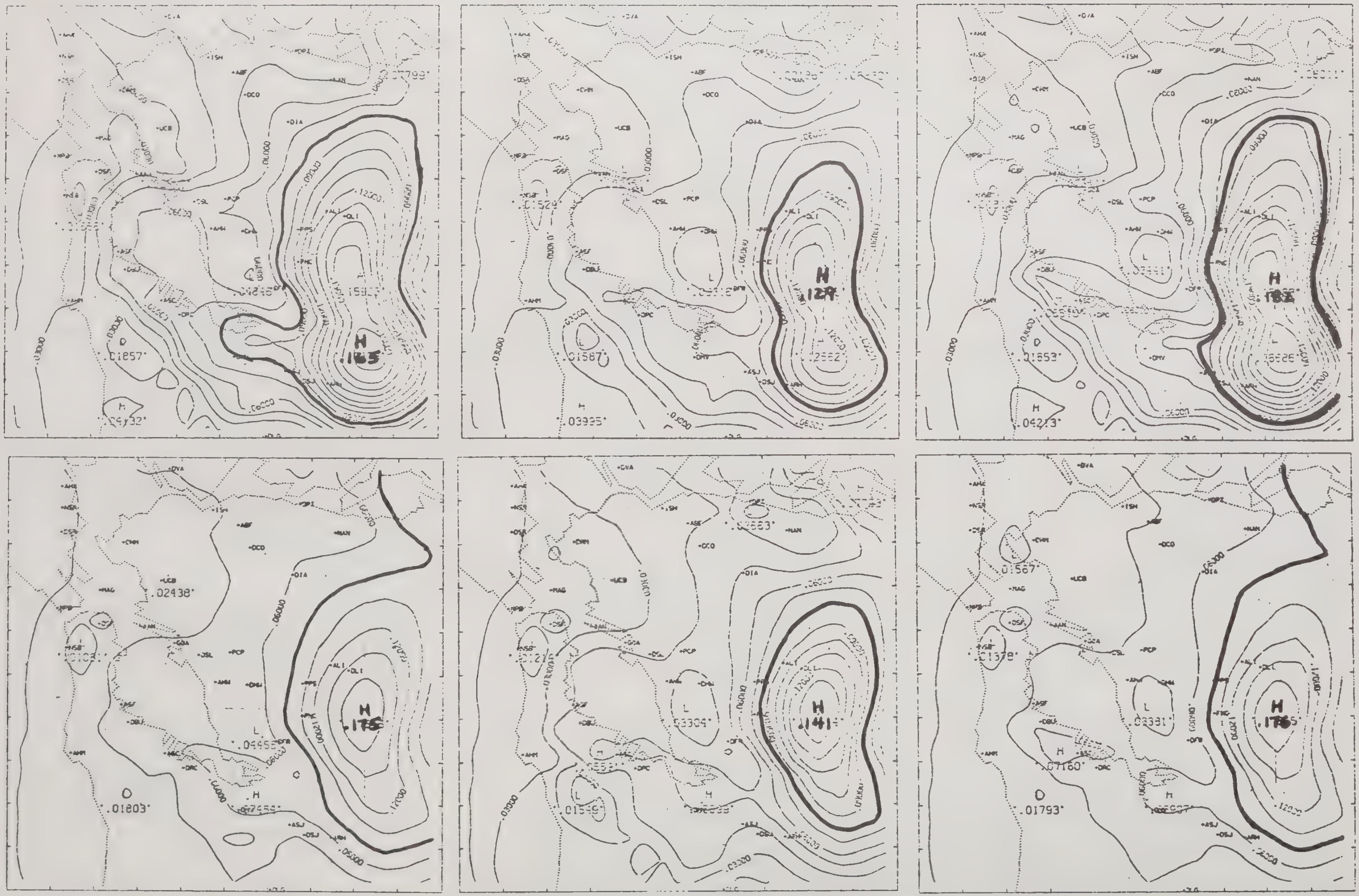
BASELINE OZONE CONTOUR MAPS, JULY 26, 1973 METEOROLOGY, NEW CHEMISTRY, WITH 0.08 PPM CONTOUR ENHANCED TO SHOW AREA EXCEEDING FEDERAL STANDARD.

YEAR 1975 1985 2000

TIME (PST)

1400

1500



-12-

FIGURE 1C

BASELINE OZONE CONTOUR MAPS, JULY 26, 1973 METEOROLOGY, NEW CHEMISTRY

WITH 0.08 PPM CONTOUR ENHANCED TO SHOW AREA EXCEEDING FEDERAL STANDARD.

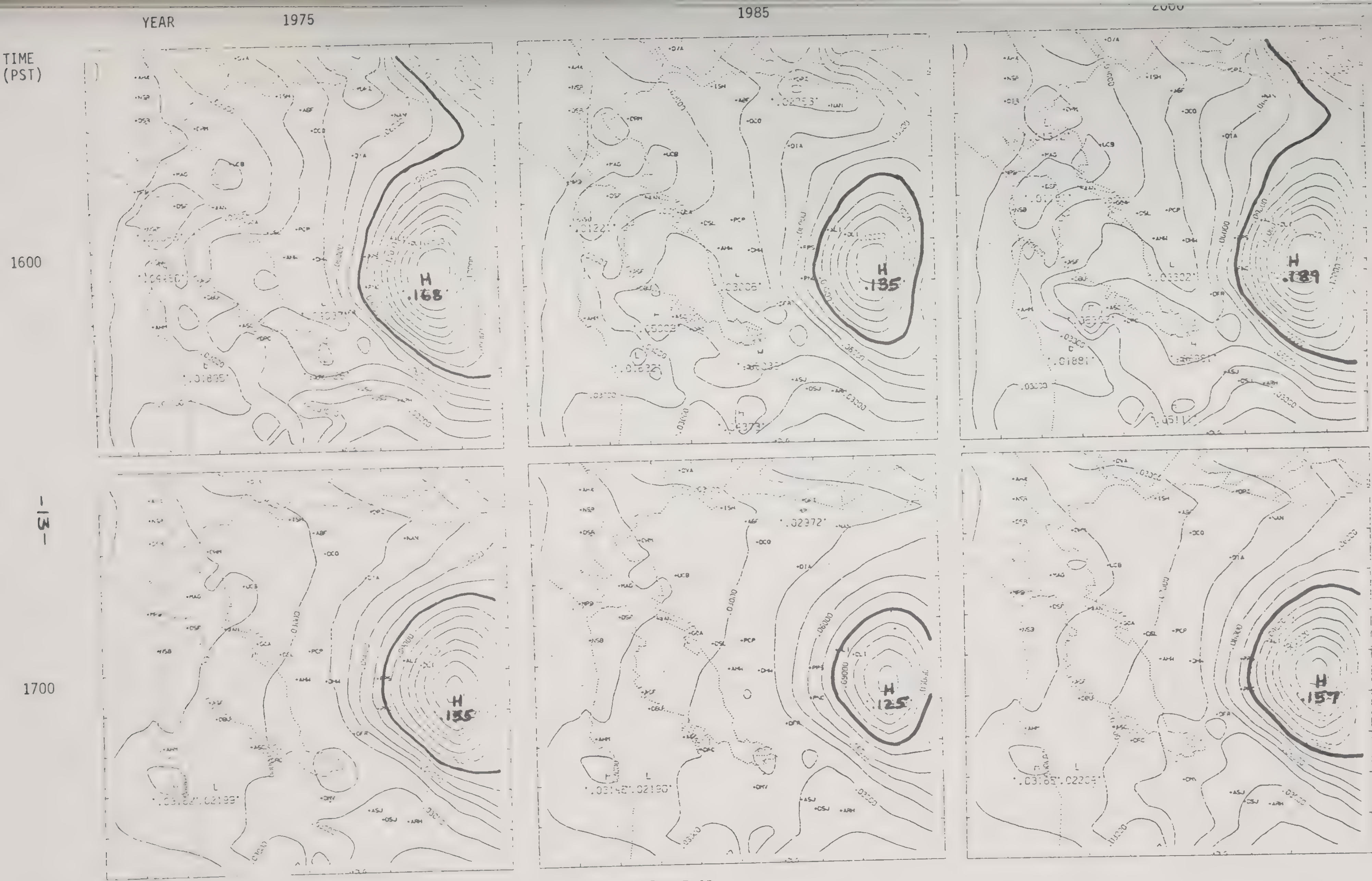


FIGURE 1D

BASELINE OZONE CONTOUR MAPS, JULY 26, 1973 METEOROLOGY, NEW CHEMISTRY

WITH 0.08 PPM CONTOUR ENHANCED TO SHOW AREA EXCEEDING FEDERAL STANDARD.

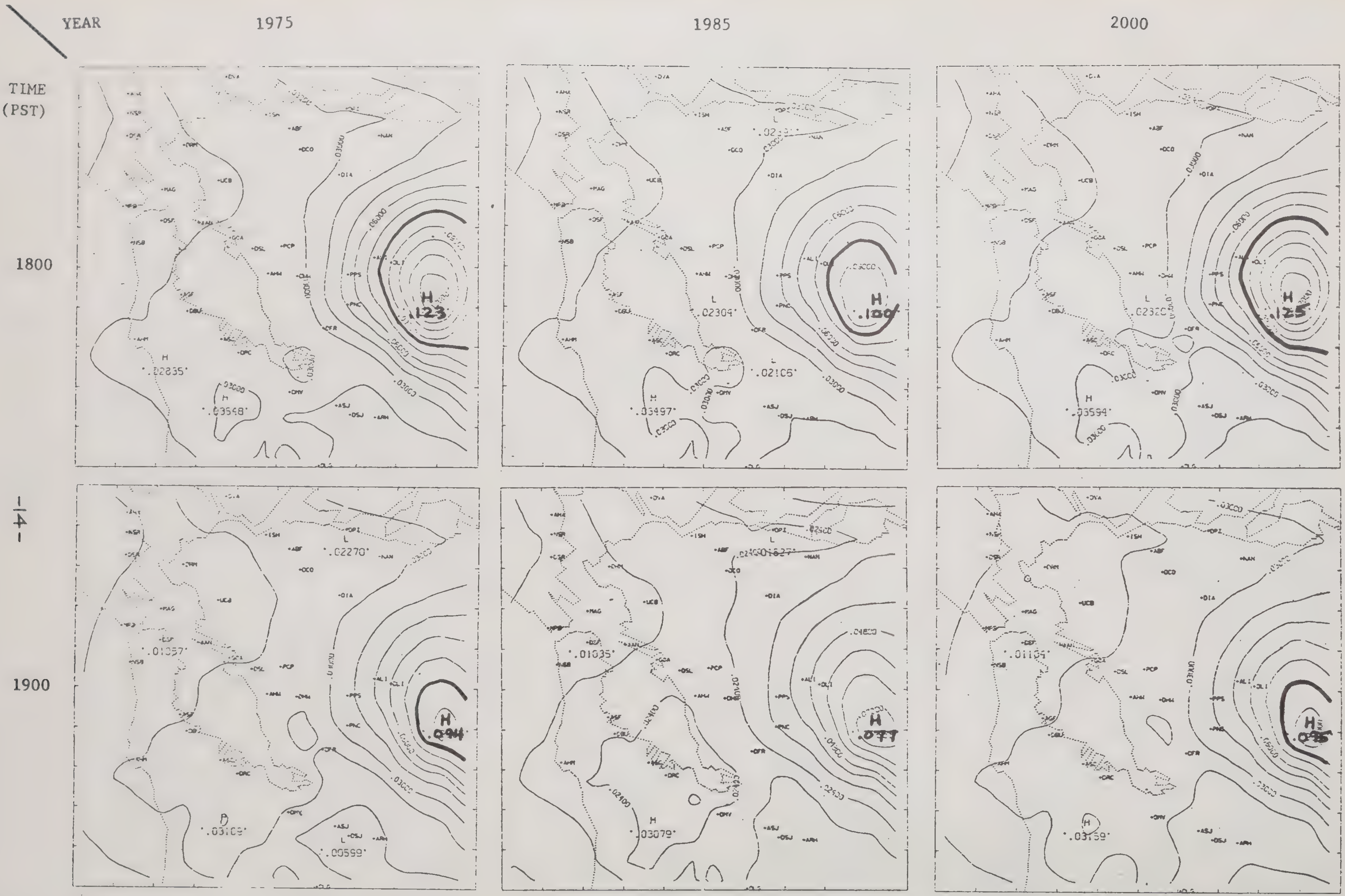


FIGURE 1E

BASELINE OZONE CONTOUR MAPS, JULY 26, 1973 METEOROLOGY, NEW CHEMISTRY, WITH 0.08 PPM CONTOUR ENHANCED TO SHOW AREA EXCEEDING FEDERAL STANDARD

YEAR 1975

TIME (PST)

1600

1700

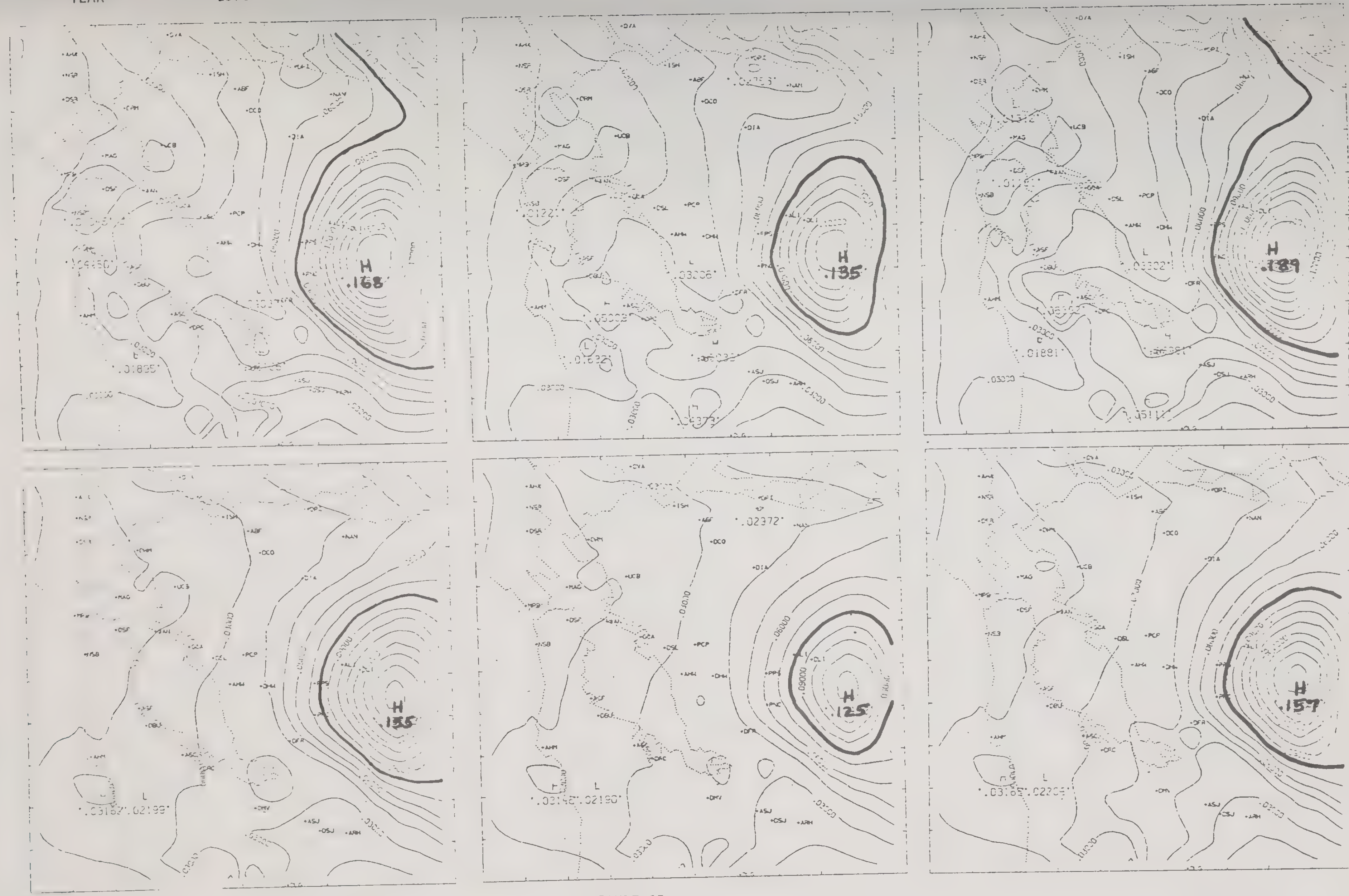


FIGURE 1D

BASELINE OZONE CONTOUR MAPS, JULY 26, 1973 METEOROLOGY, NEW CHEMISTRY

WITH 0.08 PPM CONTOUR ENHANCED TO SHOW AREA EXCEEDING FEDERAL STANDARD.

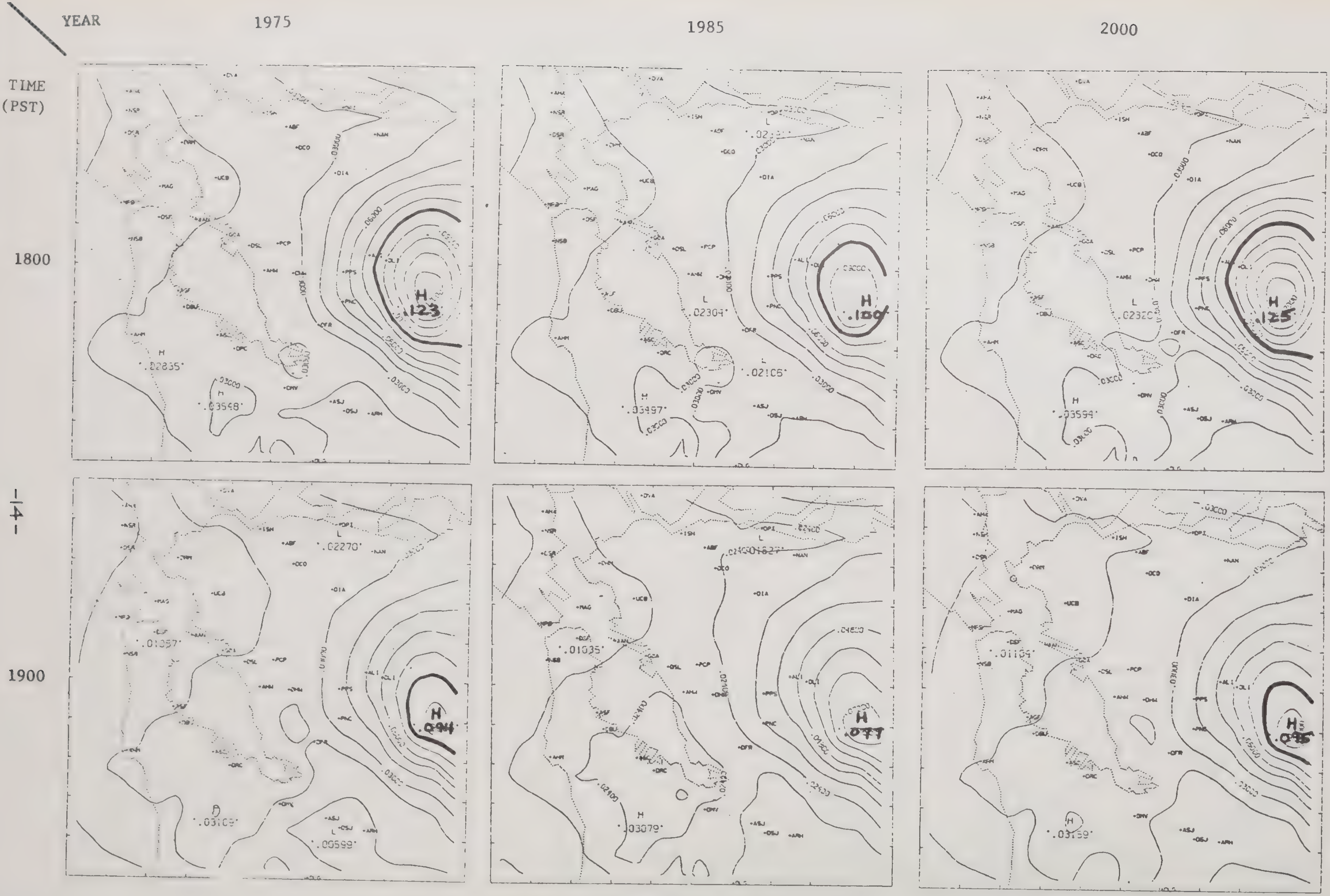


FIGURE 1E

BASELINE OZONE CONTOUR MAPS, JULY 26, 1973 METEOROLOGY, NEW CHEMISTRY, WITH 0.08 PPM CONTOUR ENHANCED TO SHOW AREA EXCEEDING FEDERAL STANDARD.

n 1985 because total organic emissions of all types are down by 228 tons/day from 975, or a reduction of about 23% of the 1975 level of 1,011 tons/day. Also, the odel calculation yields about the same amount of oxidant in the year 2000 as for 975 because total organic emissions in 2000 are back to 1975 levels.

he ozone calculations for 1985 and 2000 presume that a repeat of a day similar o the July 26 prototype would reoccur. The results have not been adjusted to a worst day"* basis in 1973. A worst case adjustment could be done for the indi- idual stations by applying the Larsen model equations and results described in echnical Memorandum 19**. A similar adjustment could be made to the regionwide igh hour results by again applying the approach of Technical Memorandum 19 or an lmost equivalent graphical technique utilizing lognormal probability paper. However, lack of such adjustment does not invalidate the results in Table 3. They tand on their merits as indicative of ozone that could be expected if a day posing significant air pollution threat to the Livermore Valley - a day like July 26, 973 - should reoccur in 1985 or 2000.

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*The worst day in 1973 occurred on June 21 when a high-hour reading of .24 ppm oxidant was observed at Mountain View. As mentioned previously the most difficult problem in adding a prototype day to the LIRAQ library is analyzing the maps of inversion base height throughout the region, because of lack of observations. Certain days in the summers of 1973 and 1974 were monitored with specially instrumented aircraft to aid in the development of the LIRAQ model. July 26, 1973 and July 24, 1974 were two such days, but neither was the day when highest oxidant for the year was recorded.

**AQMP Tech Memo 19, "Applicability of Selected Statistical/Empirical Techniques to Air Quality Analysis in the San Francisco Bay Region."

TABLE 2

LIRAQ Verification Results, New Chemistry,

1975 Emissions, 1973 Meteorology

Surface High-Hour Oxidant Concentrations, ppm

	July 26, 1973		August 20, 1973	
	Observed	LIRAQ	Observed	LIRAQ
San Francisco	.02	.02	.01	.03
San Rafael	.06	.02	.02	.03
Pittsburg	N/A	.04	.05	.05
Livermore	.18	.13	.07	.06
Fremont	N/A	.07	.05	.05
San Jose	.13	.13	.05	.06
Redwood City	.10	.09	.02	.04
Concord	.16	.06	.08	.05
Richmond	.06	.04	.02	.04
San Leandro	.11	.07	.04	.04
Los Gatos	.09	.07	.06	.05
Vallejo	.11	.05	.04	.05

Root Mean Square Errors (RMSE) in ppm and Correlation Coefficients Between Observed and LIRAQ Calculated Surface Pollutant Concentrations

	July 26, 1973		August 20, 1973	
	RMSE, ppm	Correlation	RMSE, ppm	Correlation
Oxidant/Ozone	.027	0.75	.012	0.75
Nitric Oxide	.100	0.69	.021	0.52
Nitrogen Dioxide	.040	0.56	.017	0.18
Carbon Monoxide	1.918	0.50	0.934	0.58
Total Hydrocarbons	1.635	0.43	1.113	0.59

TABLE 3

LIRAQ Baseline Results for July 26, 1973 Prototype Day

High Hour Ozone in ppm, by Station and Regionwide

	1975	1985	2000
Ozone at Highest Station	.13	.10	.13
Highest Station	Livermore	Livermore	San Jose
Individual Stations			
San Francisco	.02	.02	.02
San Rafael	.02	.02	.02
Pittsburg	.04	.03	.05
Livermore	.13 (.133)	.10	.12 (.122)
Fremont	.07	.05	.06
San Jose	.13 (.125)	.09	.13 (.128)
Redwood City	.09	.06	.07
Concord	.06	.05	.06
Richmond	.04	.03	.04
Half Moon Bay	.03	.03	.03
San Leandro	.07	.05	.06
Los Gatos	.07	.05	.07
Vallejo	.05	.04	.04
Regionwide High Hour	.17	.13	.17
Location of Regional High Hour	6 Miles* SSE of Livermore	6 Miles*SSE of Livermore	6 Miles* SSE of Livermore

*9.5 Kilometers.

AQMP/Tech Memo 18
L. Robinson
R. De Mandel

September 1977

LIRAQ EMISSIONS SENSITIVITY ANALYSIS

This technical memorandum documents procedures and results of the emissions sensitivity analyses made with the Livermore Regional Air Quality Model, LIRAQ. Results are presented for systematic variations of projected emissions in 1985 and 2000.

Purpose of an Emissions Sensitivity Analysis

Technical Memorandum 7* describes the three step procedure being followed to analyze alternative air quality strategies within AQMP manpower, schedule, and budgetary constraints. The first step requires specification of the range of total emission reductions necessary to attain the oxidant standard. The specification is, purposely, without regard to identification of actual control measures that might achieve such reductions. Its main purpose is to provide clues to the design of control strategies. An emissions sensitivity analysis accomplishes this "first step" specification by,

- o reducing baseline hydrocarbon and/or oxides of nitrogen emissions by a fixed percentage, uniformly applied,
- o applying LIRAQ** to convert the modified emissions into ozone concentrations,
- o determining the resulting regionwide high-hour ozone,
- o repeating the above operations for a lessor percentage reduction of emissions, etc., until zero percentage reduction, i.e. the baseline, is reached.

Thus obtained, regionwide high hour ozone may be adjusted and plotted as a function of percent reduction of precursor emissions; the percent reduction may then be determined to achieve the .08 ppm one hour national ambient air quality standard (NAAQS).

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*AQMP Tech Memo 7, "Development and Analysis of Alternatice Air Quality Strategies".

**AQMP Tech Memo 17, "Baseline LIRAQ Air Quality Projections" describes the operational and technical features of the LIRAQ photochemical model and its QSOR emission input files.

Issues of Interpretation

Emissions sensitivity analysis with LIRAQ provides the required percent reduction to achieve the oxidant NAAQS only for the prototype meteorological day used in the simulation. If a worse meteorological day were used, higher ozone would be calculated by LIRAQ. The days* in the LIRAQ library are not the worst case days in the year (or decade). Thus, some method is needed to adjust sensitivity analysis results to a worst case for the year basis.

A need arises for further adjustment because unavoidably, model ozone results do not exactly reproduce the geographic and time variations in observed oxidant. This "validation" problem generates the need for an adjustment that will make the sensitivity analysis results conform to the observed regionwide high hour oxidant.

The Modeling Committee considered these two issues in detail and their recommended procedures are summarized in Technical Memorandum 20.** Technical Memorandum 19*** discusses the applicability of the statistical Larsen model technique recommended in Technical Memo 20 for the adjustment to worst case meteorology. Adjusted curves are given in later sections of this memo, along with unadjusted results.

Verification is not included here as an issue of interpretation in an emissions sensitivity analysis. However, modeling committee recommendations were also followed for the verification of the "new chemistry" version of LIRAQ on the 1975 baseline runs. These results were reported in Technical Memorandum 17. The new chemistry version of LIRAQ was used for all emissions sensitivity analyses reported in this Technical Memo.

DESIGN OF THE SENSITIVITY ANALYSIS

The modeling committee considered the following factors in the design of the sensitivity analysis:

- o the relative importance of hydrocarbon versus nitric oxide precursors as indicated by preliminary LIRAQ results,
- o the relative usefulness of the two emission inventories, 1985 and 2000,
- o the representativeness of the available "high-oxidant" prototype days,

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* AQMP Tech Memo 17, "Baseline Air Quality Analyses" describes how prototype meteorological days were selected and analyzed for inclusion in the LIRAQ library.

**AQMP Tech Memo 20, "Procedure for the Interpretation of LIRAQ Air Quality Projections." This Memo also describes the function and make-up of the modeling Committee.

***AQMP Tech Memo 19, "Applicability of Selected Statistical/Empirical Techniques to Air Quality Analysis in the San Francisco Bay Region.

- o the order in which runs should be made, so that as results became available, the order in which new runs were made could be altered in an optimum fashion,

- o the heavy time pressures and concomitant need for effective and efficient LIRAQ job scheduling at Lawrence Berkeley and Lawrence Livermore Laboratories,

- o the incremental percentage reductions required of the precursors to cover the range of interest, i.e. the percentage range that as an "a priori" guess might contain attainment of the standard.

The above list can be conveniently organized into a "design space" of four "dimensions" which contains as a subset the variety of LIRAQ runs finally recommended by the modeling committee. Such a design space has:

- o two dimensions for precursor emission possibilities - one dimension for percent reductions of hydrocarbon emissions and one dimension for percent reductions of nitric oxide emissions,

- o one dimension for future-year inventory possibilities,

- o one dimension for prototype meteorological day possibilities.

Each dimension can be considered to have as many "points" along it as one wishes. In practice, the future-year inventory dimension had only two realistic possibilities, points at 1985 and 2000. The prototype meteorology dimension similarly had at that time only two feasible points, July 26, 1973 and July 2, 1970. Unlike the emission and meteorological factors, the precursor percent reduction dimensions can have an arguable variety of points. If, whatever their value, only two points are selected along each precursor dimension, the resulting design would call for $2^4=16$ runs. Discussed next is the design actually selected which called for a maximum of 6 runs.

<u>Design Selected</u>

After thorough consideration, the modeling committee selected a sensitivity analysis design which called for the following runs:

- o For the 1985 inventory and July 26, 1973 meteorology, run LIRAQ with hydrocarbon emissions alone reduced uniformly by 80% and 40% in every 5 kilometer grid square for every hour of the day - <u>two runs</u>.

- o For the 1985 inventory and July 26, 1973 meteorology, run LIRAQ with hydrocarbon emissions reduced 80% and nitric oxide emissions reduced 40%. Reductions are made uniformly in every 5-kilometer grid square, for every hour of the day and for each pollutant - <u>one run</u>.

- o For the 1985 inventory and July 26, 1973 meteorology, run LIRAQ with hydrocarbon emissions reduced 40% and nitric oxide emissions reduced 20%. Reductions are made uniformly, etc.-<u>one run</u>.

- o For the 2000 inventory and July 26, 1973 meteorology, run LIRAQ with hydrocarbon only emissions reduced uniformly by 80% and 40% in every 5 kilometer grid square for every hour of the day - <u>two runs</u>, which

may or may not need to be made after examination of the 1985 and July 26, 1973 meteorology "hydrocarbon only" runs.

Thus six was the maximum and four was the minimum number of LIRAQ runs called for by the above schedule. The modeling committee arrived at these selections by application of the following criteria and reasoning;

- o Limited results hinted at the importance of "hydrocarbon only" reductions, but the effect of simultaneous nitric oxide reductions also had to be established.
- o Limited preliminary results indicated that an 80% hydrocarbon reduction more than achieved the standard. Extrapolation and interpolation suggested the 40% reduction and 80%/40% and 40%/20% reduction combinations.
- o The 1985 inventory was favored over 2000 because of unavoidable longer term assumptions in the latter, particularly with regard to nitric oxide emissions from major point sources.
- o The July 26, 1973 meteorology was favored over the July 2, 1970 meteorology because of suspected recirculation problems with prior day pollutants for the latter. Both dates had the same observed high-hour oxidant, .18 ppm.

Runs Actually Made

The modeling committee had incorporated the option of modifying the schedule to take advantage of information as it became available. In response to this foresight, design modifications were made when the first runs indicated that hydrocarbon only reductions were more effective than simultaneous hydrocarbon and nitric oxide reductions. Thus two more hydrocarbon only reductions were scheduled for the 1985 emission inventory and July 26, 1973 meteorology. These were runs for 60% and 20% reductions; they nicely filled out the range form 0% reduction (baseline) through 80% reduction, in 20% increments. One of the year 2000 "hydrocarbon only" runs was dropped, the 40% reduction run, so that results could be obtained in the time available.

Future Runs

Other runs will be made, partly because the original design space can be further explored with benefit and partly because a fifth dimension has been added to it, an axis with two points to represent central Bay modeling and north Bay modeling (i.e. a shifted grid). Work underway or planned includes;

- o A verification run of July 24, 1974 meteorology with 1975 emissions,
- o Baseline and sensitivity runs with July 24, 1974, when successfully verified,

- o Baseline and sensitivity runs with July 26, 1973 meteorology on the north Bay grid,

- o A sensitivity run with July 26, 1973 meteorology, 1985 emissions, central Bay grid, and 40% reduction in nitric oxide emissions only.

July 26 meteorology is being used on the north Bay grid as an interim measure; it is a high-oxidant day for the north Bay, but not the worst case. July 25, 1975 is being developed as prototypical of worst case north Bay oxidant conditions.*

The high-hour oxidant observed on July 26, 1973 for the north Bay was .12 ppm at Napa and Fairfield. For comparison, the high hour oxidant observed on July 25, 1975 for the north Bay was .16 ppm at Napa and .17 ppm at Sonoma.

RESULTS

In the following discussions, percent reduction of emissions has been calculated as a reduction from the baseline emissions listed in Technical Memo 17 for the appropriate future-year. As an example, an 80% reduction of hydrocarbon only emissions in future-year 2000 means that the total of 1016.70 tons/day of all organics in 2000** has been reduced by 0.80 times 1016.70 or 813.36 tons/day. Thus LIRAQ operated on only the remaining 203.34 tons/day of organic emissions. Of that remainder, 43.20 tons/day were alkenes, 150.68 tons/day were alkanes, and 9.46 tons/day were aldehydes.

Sensitivity analysis results are discussed by variation in future-year and by variation in percent reduction of precursor emissions.

Sensitivity Results Compared by Future-year

Table 1 gives the results of holding constant the percent reduction in hydrocarbon only emissions and the prototype meteorology, while varying the future-year emission inventory. The last two columns of Table 1 show that the regionwide high hour ozone calculated by LIRAQ is at background levels, .04 ppm, in both 1985 and 2000, when an 80% reduction is applied to "hydrocarbon only" emissions for both years, and when the same prototype day, July 26, 1973, is used for both simulations. A similar result is likely for 1975 - although no such run was made - because total organic emissions in 1975 are about the same as 2000.

The regionwide high hours for 1985 and 2000 in Table 1 have not been adjusted for worst case meteorology and validation factors. The adjustment may be made by multiplying 0.04 ppm times the dimensionless factor 1.41. This factor

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*Technical memo 17 describes the process of adding prototype days and certain difficulties that can occur.

**See the table titled "Baseline Emission Totals" in Tech Memo 17.

Table 1. Emission Sensitivity Results Compared by Future-year Given 80% HC Only Reduction and July 26, 1973 Meteorology

	Maximum Oxidant Concentrations (ppm) by Station		
	1975* No Reduction	1985* No Reduction	2000* No Reduction
Location of Regional High Hour Ozone	9.5 Km SSE of Livermore	Near Montezuma Hills	Near Montezuma Hills
Regionwide High Hour, ppm	.17	.04	.04
Monitoring Station with Highest Ozone	Livermore	Vallejo	Half Moon Bay
High Hour Ozone at Highest Station	.13	.03	.03
High Hour Ozone by Monitoring Station, ppm			
San Francisco	.02	.02	.01
San Rafael	.02	.02	.02
Pittsburg	.04	.02	.03
Livermore	.13	.03	.02
Fremont	.07	.01	.01
San Jose	.13	.01	.01
Redwood City	.09	.03	.03
Concord	.06	.03	.03
Richmond	.04	.02	.02
Half Moon Bay	.03	.03	.03
San Leandro	.07	.03	.02
Los Gatos	.07	.02	.02
Vallejo	.05	.03	.03

* i.e., base year results.

** 80% reduction in hydrocarbon emissions applied uniformally throughout region and to each hour of day.

is derived by multiplying 4/3, the correction for worst case, times 18/17, the correction for validation variation. Technical Memorandum 20 gives the basis for the adjustment procedure and the numerical values appropriate for the July 26, 1973 prototype day. For 1985 and 2000, the adjusted result is .06 ppm for the regionwide high hour. These sensitivity analysis results lead to the conclusion that an overall 80% reduction in organic emissions is more than enough to achieve the standard of 0.08 ppm in 1985 and 2000. The results do not indicate how such a reduction could in practice be achieved. A variety of control strategies would need to be examined to make such a determination.

Table 1 also gives simulated high hour ozone by monitoring station for representative locations. The entries are unadjusted for worst case or other variation. As they stand, the numbers for 1985 and 2000 are quite small for all stations. Some interesting contrasts appear. Thus Fremont and San Jose locations generate only 0.01 ppm of ozone while the coastal location of Half Moon Bay generates 0.03 ppm of ozone. This occurs in both 1985 and 2000 simulations. The Half Moon Bay number is attributed to the background level of ozone that LIRAQ generates with its present boundary conditions, because air reaching Half Moon Bay on July 16, 1973 was only from over the ocean to the west where there are no precursor emissions. The lower than background Fremont and San Jose numbers are attributed to "NOx quenching", a flooding of the area with the unaltered nitric oxide emissions and consequent elimination of nearly all model generated ozone. Note that the baseline run for 1975 shows both Fremont and San Jose experiencing considerably higher levels of ozone, as is typical for both locations on an episode day like July 26, 1973.

Sensitivity Results Compared by Percent Reduction In Precursors

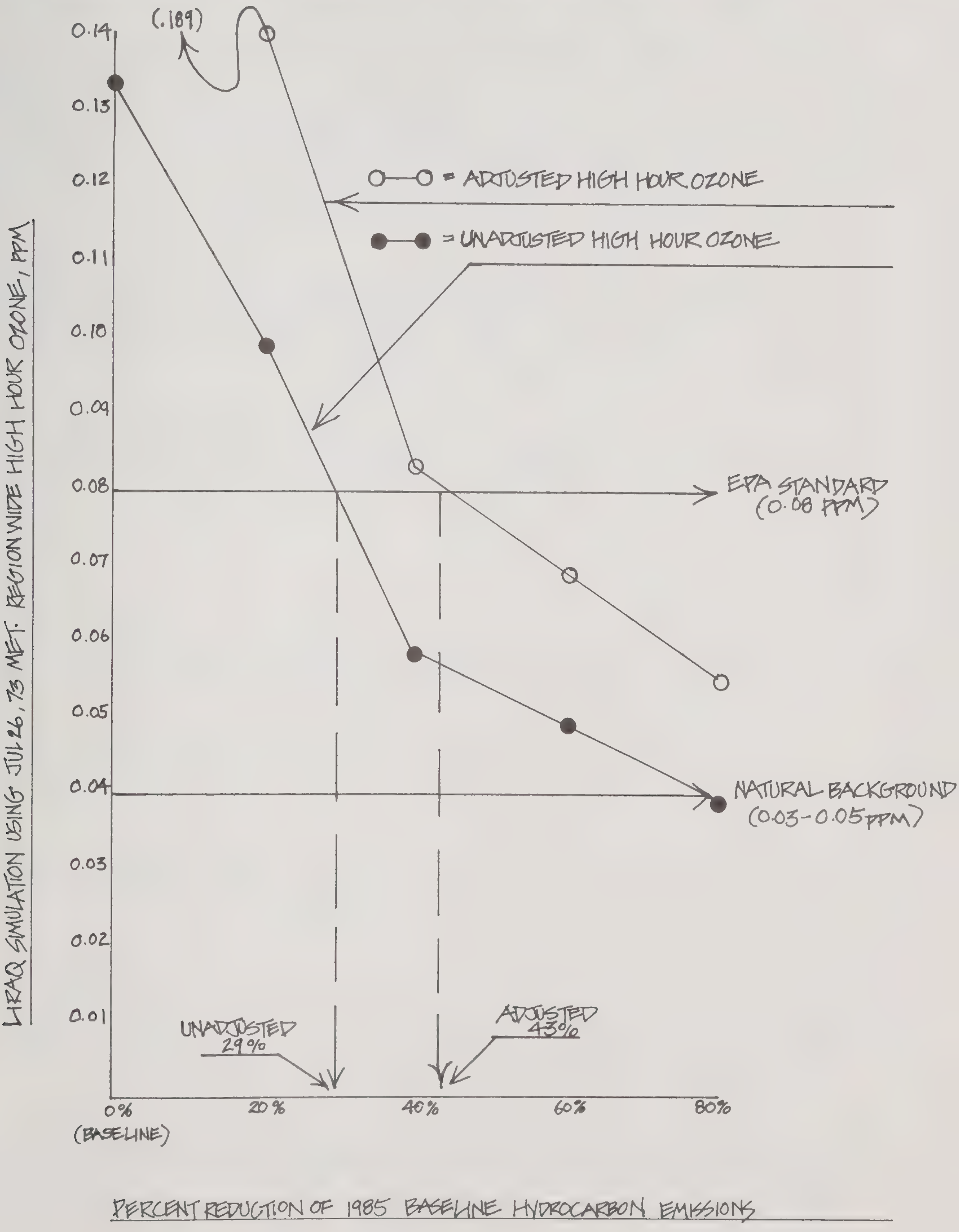
Table 2 gives the result of holding constant the future-year emission inventory and the prototype meteorology, while varying the percent reductions in precursor emissions. Each column of the table corresponds to a different combination of percent reductions in hydrocarbon and nitric oxide emissions. The first five columns show zero for percent reductions in NO emissions, so results in these columns pertain to reductions in only hydrocarbon emissions, with the first column being simply the 1985 baseline results. The last two columns give results for simultaneous reduction in hydrocarbon and nitric oxide emissions. All results in Table 2 are for the same inventory year, 1985, and same prototype meteorology, July 26, 1973.

The regionwide high hour results show that the hydrocarbon only percent reductions will achieve the standard of 0.08 ppm somewhere between 20% and 40%. Figure 1 is a plot of regionwide high hours versus percent reduction of the hydrocarbon only emissions. Two curves are shown, one unadjusted for worst case and validation variation and the other adjusted for these features by multiplication of the region wide high hours by 1.41. These curves allow a more precise interpolation of percent reduction in hydrocarbon only emissions to meet the standard. Figure 1 shows the required number to be 29% on an unadjusted basis and 43% on an adjusted basis.

Table 2. Emission Sensitivity Results Compared by Percent Reductions in Hydrocarbon and Nitric Oxide Precursors, Given 1985 Emissions Inventory and July 26, 1973 Meteorology

% Reduction HC % Reduction NO	0% 0%	20% 0%	40% 0%	60% 0%	80% 0%	40% 20%	80% 40%	
Location of Regional High Hour Ozone	6 MI SSE LIV	6 MI SSE LIV	6 MI SE LIV	6 MI SE LIV	Near MH	6 MI SSE LIV	Near MH	LIV=Livermore MH =Montezuma Hills
Regionwide High Hour Ozone in ppm	.13	.10	.06	.05	.04	.08	.04	
Monitoring Station with Highest Ozone	LIV	LIV	LIV	LIV	VA	LIV	LIV	VA = Vallejo LIV = Livermore
High Hour Ozone at Highest Station, ppm	.10	.08	.05	.04	.03	.07	.04	
High Hour Ozone by Monitoring Sta., ppm								
San Francisco	.02	.02	.02	.02	.02	.02	.02	
San Rafael	.02	.02	.02	.02	.02	.02	.02	
Pittsburg	.03	.03	.03	.02	.02	.03	.03	
Livermore	.10	.08	.05	.04	.03	.07	.04	
Fremont	.05	.03	.02	.02	.01	.03	.02	
San Jose	.09	.05	.02	.02	.01	.04	.02	
Redwood City	.06	.04	.03	.03	.03	.04	.03	
Concord	.05	.04	.03	.03	.03	.04	.03	
Richmond	.03	.03	.02	.02	.02	.03	.03	
Half Moon Bay	.03	.03	.03	.03	.03	.03	.03	
San Leandro	.05	.04	.03	.03	.03	.04	.03	
Los Gatos	.05	.04	.02	.02	.02	.03	.02	
Vallefo	.04	.04	.03	.03	.03	.04	.04	

FIGURE 1. **PLOTS OF UNADJUSTED AND ADJUSTED REGIONWIDE HIGH HOUR OZONE AS A FUNCTION OF % REDUCTIONS OF 1985 HC EMISSIONS**



LHR 10/2/77

The sixth column of Table 2 shows that the regionwide high hour for a 40% hydrocarbon emissions reduction simultaneous with a 20% nitric oxide emissions reduction is 0.08 ppm of ozone. This number is 0.02 ppm greater than the regionwide high hour for 40% only emission reduction. Figures 2,3, and 4 have been prepared to highlight this effect. Figure 2 shows the east-west traverse AA' along which map ozone* has been plotted in Figure 3. Figure 2 is the baseline map for 1985 emissions and July 16, 1973 meteorology at 1500 PST, the hour when the highest map ozone occurred 9.5 kilometers SSE of Livermore. The section line AA' is through this point of maximum map ozone, as is the north-south traverse BB'. The curves labeled "baseline" in fugures 3 and 4 represent ozone cross-sections through this ozone "high", along traverses AA' and BB' respectively.

Similarly, for the 1985 inventory and July 26, 1973 meteorology, the other curves in Figures 3 and 4 represent ozone cross-sections along identical traverses AA' and BB' for LIRAQ map outputs obtained when the emissions input is reduced by 20% HC, 40% HC, 60% HC, 80% HC, and 40% HC/20% NO. Curve labels correspond to the various percent reductions.

The six curves in Figures 3 and 4 clearly show the geographic variation of the various percent reductions in precursor emissions. In particular the 40% HC/20% NO curve is shown to exceed the 40% HC only curve almost everywhere along the two cross-sections.

Implications for Control Strategies

The main implications are:

- o reduction of hydrocarbon emissions alone is more effective than joint reduction of hydrocarbon and nitric oxide emissions, for the percentages examined,
- o "Nitric oxide quenching" is a likely explanation for this result,
- o a 43% reduction of hydrocarbon emissions will attain the standard in 1985,
- o by extrapolation of this 1985 result*, a 56% reduction of hydrocarbon emissions will attain the standard in 2000.

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*"map ozone" is to be distinguished from "hourly averaged" ozone. The latter has been averaged over one hour in time. Map ozone is read directly from maps like Figure 2 and is not averaged over one hour. Map ozone is usually 0.005 to 0.015 ppm higher than hourly averaged ozone.

**The calculation is to apply the 43% reduction to total 1985 organic emissions given in Technical Memo 17. This leaves 1985 total organic emissions at approximately 450 tons/day. If a 56% reduction is applied to total 2000 organic emissions in Technical Memo 17, the same remainder is obtained, 450 tons/day.

The conclusion should not be reached that minimizing NOx emissions controls, to take advantage of NO quenching, is a viable strategy, for two reasons:

- a California standard presently exists for one hourly averaged nitrogen dioxide, which is exceeded in the region,
- the EPA is presently examining the criteria for a one to three hourly averaged nitrogen dioxide standard, in addition to the present annual average standard for nitrogen dioxide. EPA could issue such a standard in 1978.

FIGURE 2 BASELINE MAP AT 1500 PST FOR 1985 EMISSIONS AND JULY 26, 1973 METEOROLOGY, SHOWING EAST-WEST SECTION LINE AA' AND NORTH-SOUTH SECTION LINE BB'

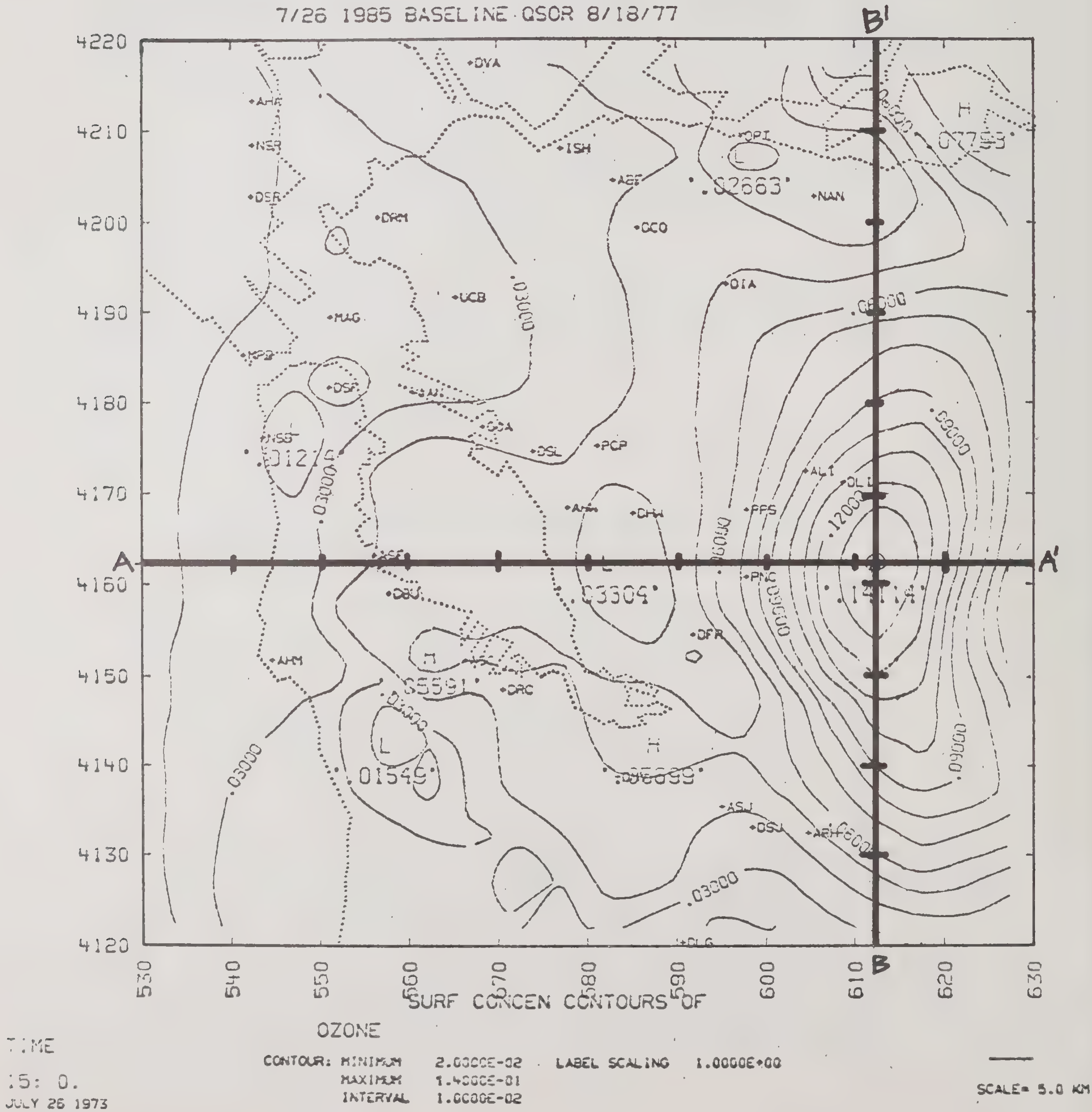


FIGURE 3 **EMISSION SENSITIVITY RESULTS COMPARED BY VARIOUS PERCENT REDUCTIONS ALONG SECTION AA' OF FIGURE 2**

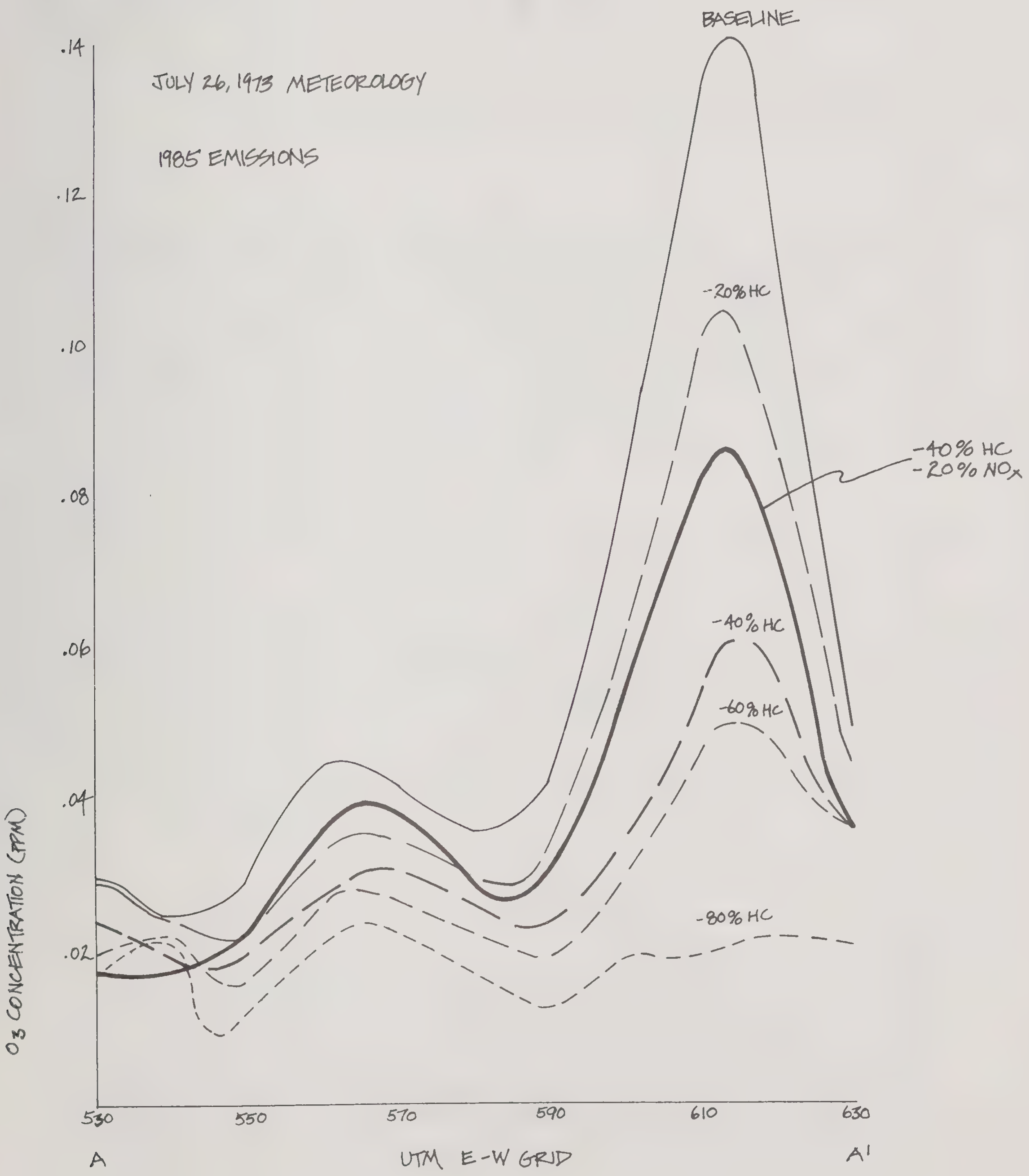
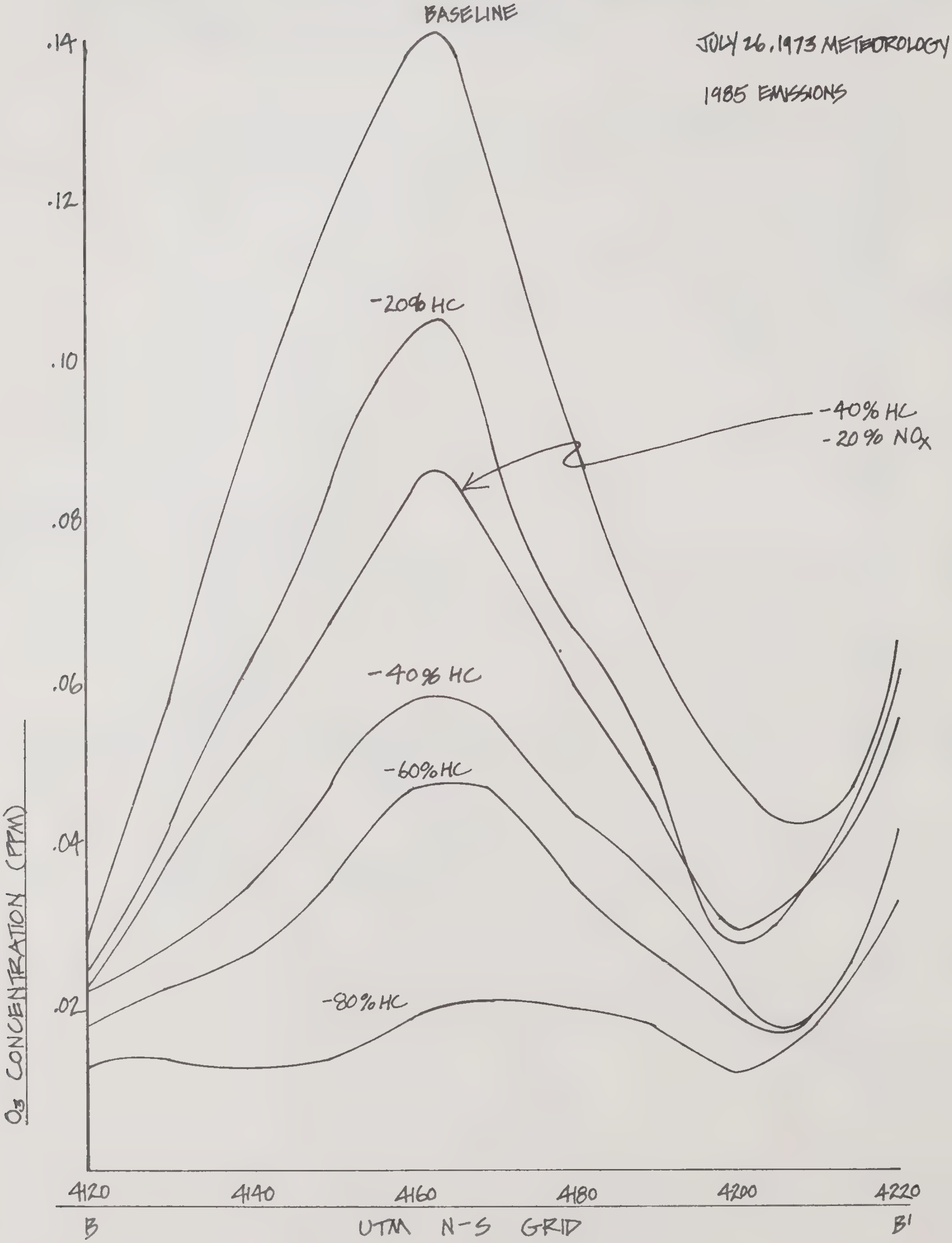


FIGURE 4 **EMISSION SENSITIVITY RESULTS COMPARED BY VARIOUS PERCENT REDUCTIONS ALONG SECTION BB' OF FIGURE 2**



AQMP Tech Memo 19
J.S.L. Fong

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APPLICABILITY OF SELECTED STATISTICAL/EMPIRICAL TECHNIQUES TO AIR QUALITY ANALYSIS IN THE SAN FRANCISCO BAY REGION

The purpose of this paper is to document the evaluation of two data-oriented techniques for air quality analysis in the Bay Area. The first technique evaluated is the relatively well-known Larsen model. The results of Larsen model calculations are presented using 1975 base year air quality monitoring data. In addition, a brief description of the theoretical basis of the Larsen model and an assessment of the validity of its underlying "lognormal" assumption are presented. The second technique, known as the ozone isopleth technique, was recently developed by the Environmental Protection Agency for potential application to photochemical oxidant analyses. Both the technique and the monitoring data and procedures used to apply the technique in the Bay Area are described.

The general conclusions of the work described in this paper are as follows:

- In most cases, the lognormal assumption, and hence the Larsen model, is valid in the Bay area. This is particularly true for carbon monoxide, nitrogen dioxide, and particulate matter. For oxidant fourteen stations exhibit lognormally distributed oxidant values while six stations exhibit minor deviations from lognormal. For sulfur dioxide the lognormal assumption is valid for five of eight stations.

- Based on data selected from logical sets of precursor and oxidant station combinations, the EPA zone isopleth method was found to be not applicable to the Bay Area.

The Larsen Model

The Larsen model is a statistical approach for estimating annual averages and expected maximum concentrations in a given area based on historical expected maximum concentrations in a given area based on historical monitoring data.(1) The basic concepts of this approach are based on statistical and distributional theories, and the validity of model assumptions and results have been assessed by many researchers.(2),(3),(4),(5) The applicability of the approach to the Bay Area was assessed since sufficient sampled air pollutant data is available throughout the region. This model could potentially be applied to all pollutants of interest, while the overall costs to analyze, validate, and implement are minimal.

Summary and Results

Using the Larsen Model, the base year, 1975 annual averages and expected maximum concentrations of each pollutant for various averaging times at each station in the Bay Area were obtained.* The results are recorded in the following tables:

Table 1 is the summary of calculations for Carbon Monoxide
Table 2 is the summary of calculations for Nitrogen Dioxide.
Table 3 is the summary of calculations for Sulfur Dioxide.
Table 4 is the Summary of calculations for total oxidants.
Table 5 is the summary of calculations for particulates.

In addition, the approximate geographic distribution of the standard geometric deviation (Sg) for each pollutant is summarized in Figures 1 through 5. The significance of this parameter is discussed in subsequent sections as part of the theoretical background of the Larsen model.

Model Development and Structure

The Larsen Model is based on comprehensive analyses of air pollutant data using statistical theory. The essential developmental concepts and structure for our estimations are summarized below:

1. A random hourly pollutant concentration consisting of n measurements is obtained. This random set is denoted by $\{C_1, C_2, \ldots, C_n\}$. The Model assumes (or concluded by Larsen) that $\{C_i\}$ is lognormally distributed regardless of pollutant or averaging time, that is, the probability density function of C_i is:

$$f(c;\mu,\sigma) = (2\pi\sigma c)^{-1} e^{-\frac{1}{2}\left(\frac{\ln c-\mu}{\sigma}\right)^2}, \quad c>0,$$

   where μ, σ are model parameters.

2. Since $\{C_i\}$ is lognormally distributed, one can normalize the C_i values--that is, transform the $\{C_i\}$ into a standard normal probability function--with the following transformation equation:

$$z = \frac{\ln c - \mu}{\sigma}$$

   Where the random variable Z was a unit normal distribution. Taking the antilogarithm on both sizes, the following formula results:

$$c = mg \cdot Sg^{z},$$

   Where $mg = e^{\mu}$ called the geometric mean,
   $Sg = e^{\sigma}$ called the standard geometric deviation.

   This is the central structural formula in the model used for the estimation of the expected maximum concentration for each pollutant.

*Using summary data from California Air Resources Board(9)

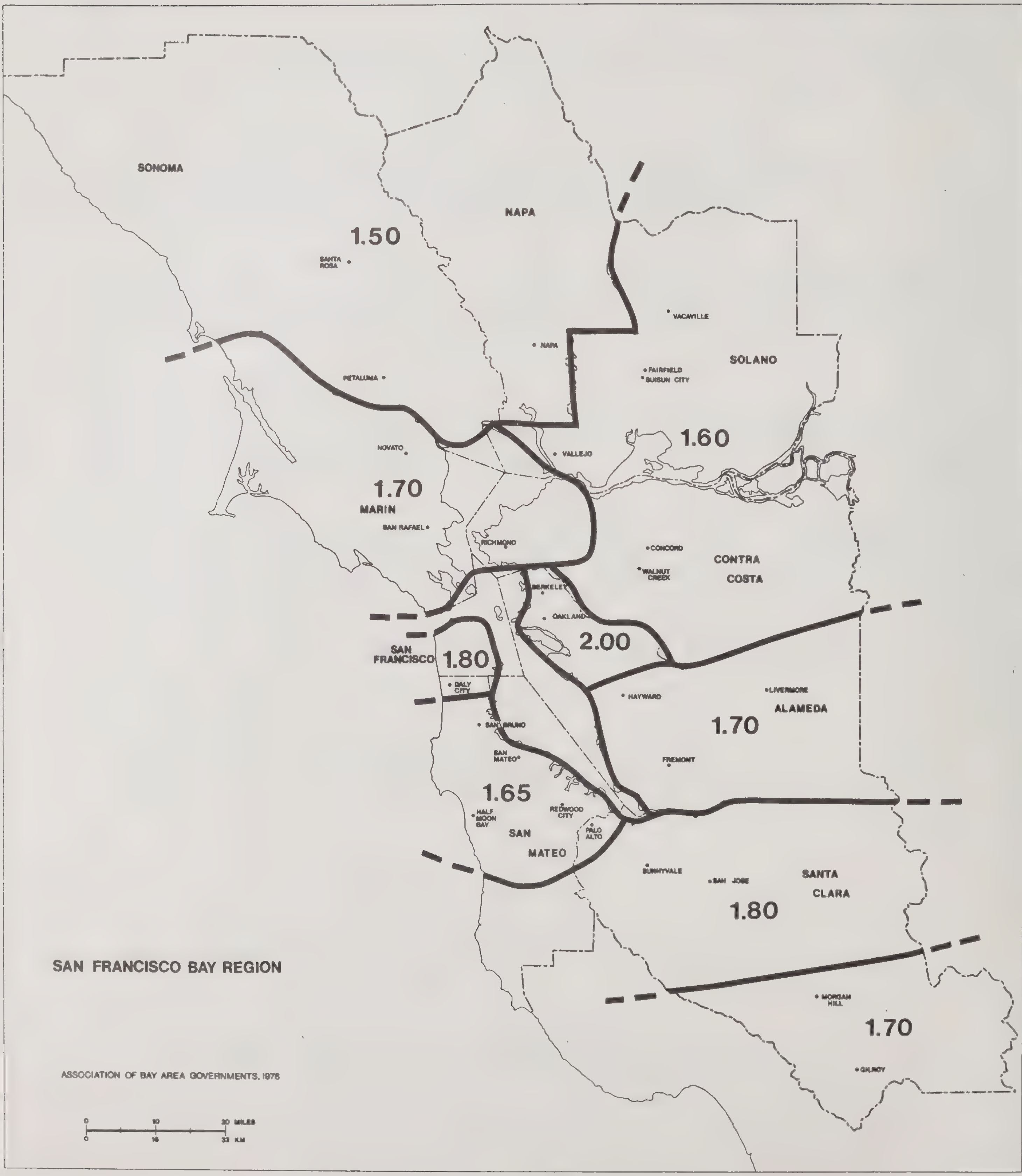
POLLUTANT: CARBON MONOXIDE

Year: 1975

Unit: ppm

Station	Expected $C_{max, 1\text{-}hr}$	Number of Times > 35	Expected $C_{max, 8\text{-}hr}$	Number of Times > 9	Expected $C_{max, 12\text{-}hr}$	Number of Times > 10
Concord	15.0	0	9.9	1	9.1	0
Fremont	10.9	0	7.0	0	6.4	0
Gilroy	10.1	0	7.0	0	6.5	0
Livermore	14.1	0	8.8	0	8.0	0
Napa	12.0	0	8.3	0	7.7	0
Oakland	19.2	0	10.6	1	9.5	0
Pittsburg	12.0	0	7.3	0	6.6	0
Redwood City	21.0	0	12.2	2	11.0	1
Richmond	11.0	0	7.3	0	6.7	0
San Francisco	31.4	0	15.3	4	13.3	1
San Jose	27.5	0	15.2	6	13.6	2
San Rafael	16.0	0	10.5	1	9.6	0
Santa Rosa	14.0	0	9.5	0	8.8	0
Sunnyvale	18.7	0	11.0	1	9.9	0

Table 1. Summary of estimations for Carbon Monoxide



GEOGRAPHIC DISTRIBUTION OF STANDARD GEOMETRIC DEVIATION (Sg) VALUES FOR CARBON MONOXIDE.

Pollutant: Nitrogen Dioxide (NO_2)

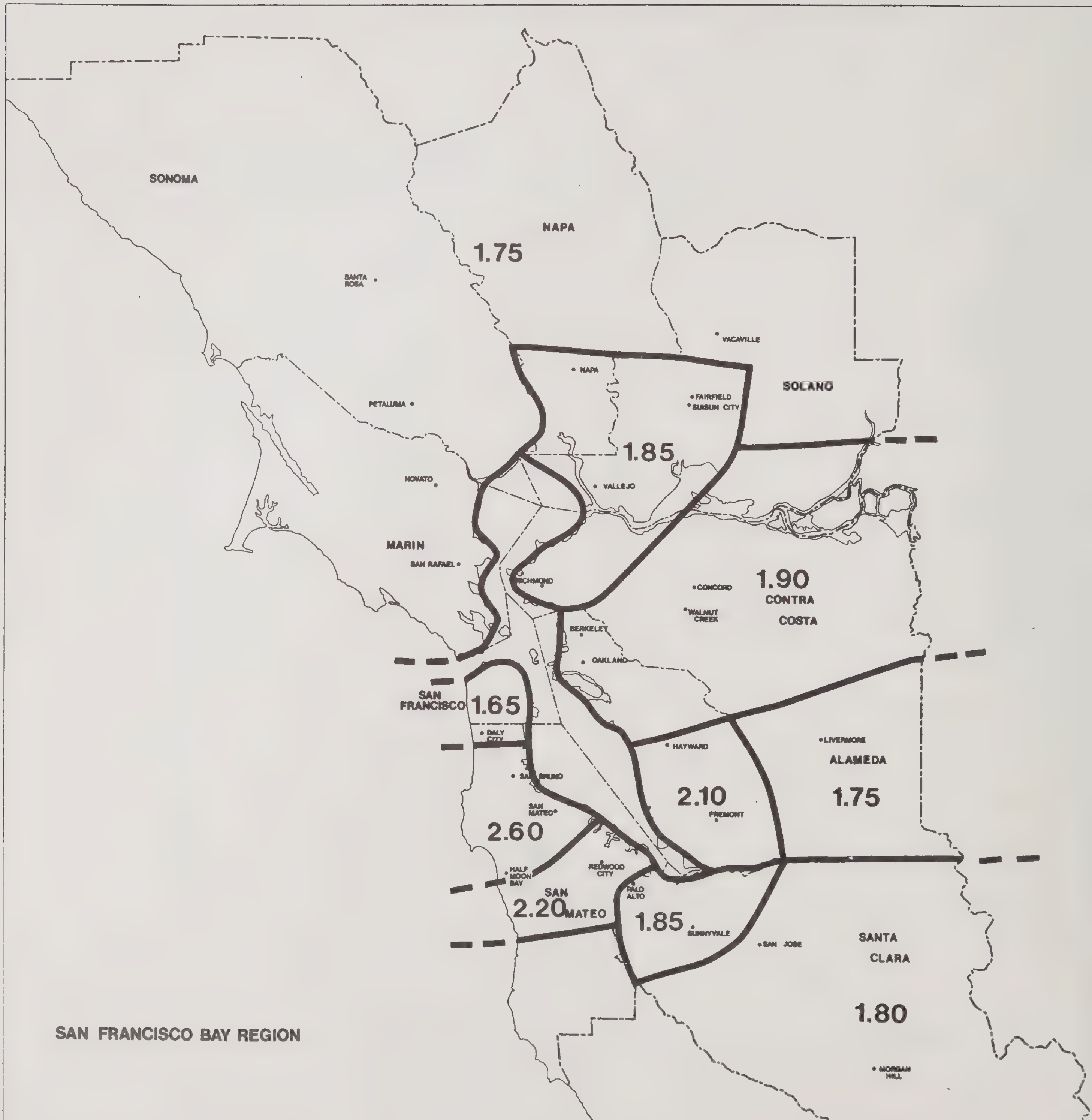
Year: 1975

Unit: ppm

Station	Expected $C_{max,1\text{-}hr.}$	Number of Times > .25	Expected Annual* Arith. Mean
Burlingame	.18	0	.019
Concord	.22	0	.034
Fremont	.38	4	.048
Gilroy	.18	0	.022
Livermore	.19	0	.035
Napa	.14	0	.028
Oakland	.24	0	.029
Pittsburg	.17	0	.026
Redwood City	.33	1	.044
Richmond	.23	0	.035
San Francisco	.28	0	.037
San Jose	.30	1	.046
San Rafael	.15	0	.039
Santa Rosa	.18	0	.026
Sunnyvale	.31	2	.046
Vallejo	.17	0	.025

*Annual arithmetic mean for National Standard = .05 ppm

Table 2. Summary of estimations for Nitrogen Dioxide



GEOGRAPHIC DISTRIBUTION OF STANDARD GEOMETRIC DEVIATION (Sg) VALUES FOR NITROGEN DIOXIDE.

POLLUTANT: Sulfur Dioxide (SO_2)

Year: 1975

Unit: ppm

Station	Expected $C_{max, 1\text{-}hr.}$	Number of Times > .5	Expected $C_{max, 3\text{-}hr.}$	Number of Times > .5	Expected $C_{max, 24\text{-}hr.}$	Number of Times > .04	Expected Annual* Arithmetic Mean
Concord	.092	0	.063	0	.030	0	.005
Crockett	.62	1	.360	0	.130	14	.011
Napa	.092	0	.058	0	.025	0	.003
Pittsburg	.15	0	.065	0	.036	0	.008
Richmond	.16	0	.098	0	.040	1	.004

*Annual arithmetic mean for National Standard = .03 ppm

Table 3. Summary of estimations for Sulfur Dioxide.

(Due to the relatively sparse network of stations for sulfur dioxide regionwide, and the fact that a total of only five stations exhibited lognormally distributed data, no map was produced for sulfur dioxide.)

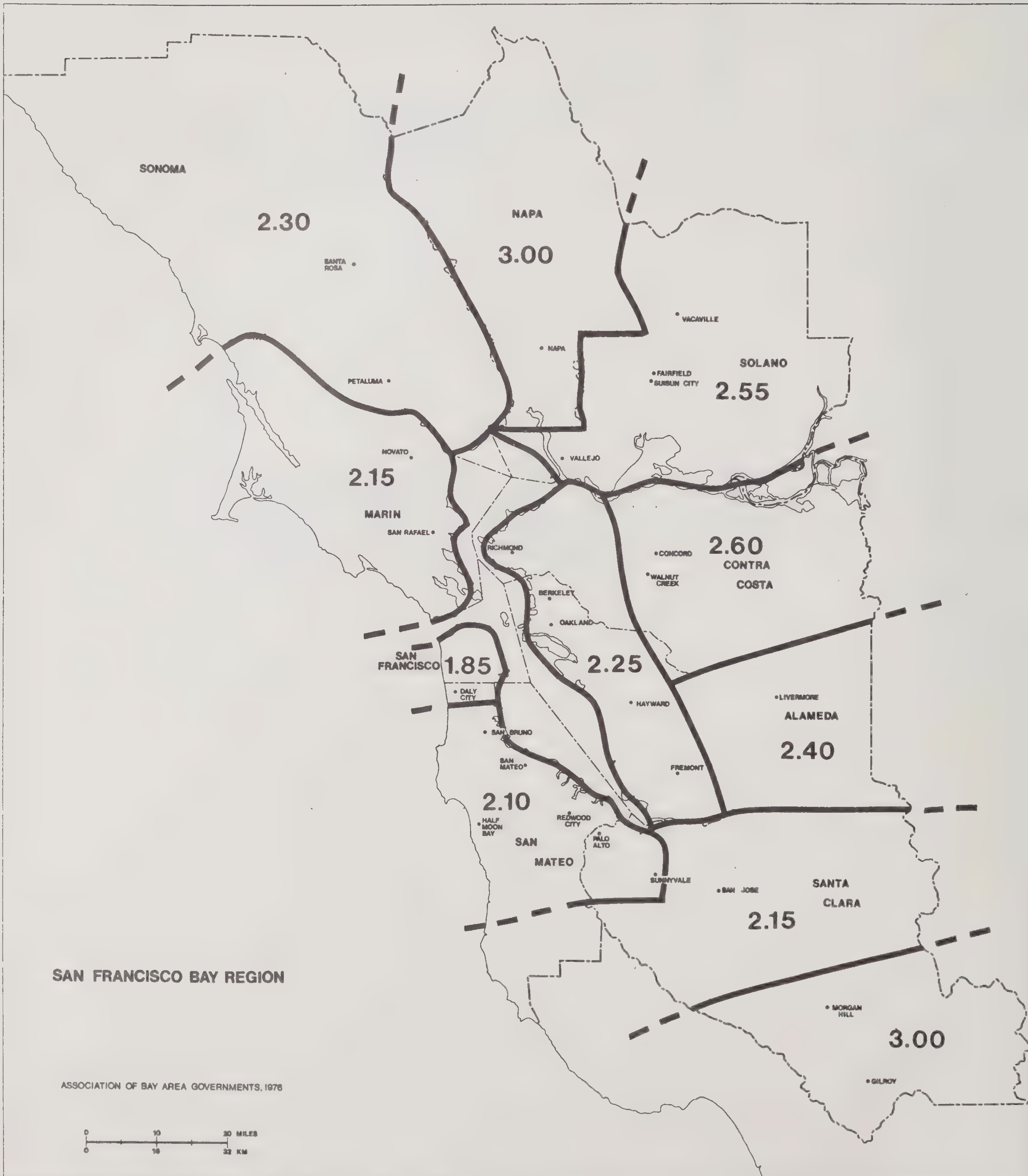
POLLUTANT: TOTAL OXIDANTS

Year: 1975

Unit: ppm

Station	Expected $C_{max.}$ 1-hr.	Number of Times > .08
Concord	.15	21
Fairfield	.11	8
Fremont	.20	62
Gilroy	.15	24
Hayward	.23	154
Livermore	.17	48
Los Gatos	.15	29
Mt. View	.22	79
Napa	.17	40
Oakland	.10	2
Petaluma	.11	6
Pittsburg	.12	9
Redwood City	.13	13
Richmond	.10	3
San Francisco	.05	0
San Jose	.19	70
San Leandro	.15	39
San Rafael	.13	6
Santa Rosa	.10	3
Sunnyvale	.22	90

Table 4. Summary of estimations for Total Oxidants



GEOGRAPHIC DISTRIBUTION OF STANDARD GEOMETRIC DEVIATION (Sg) VALUES FOR OXIDANTS.

Pollutant: Particulates

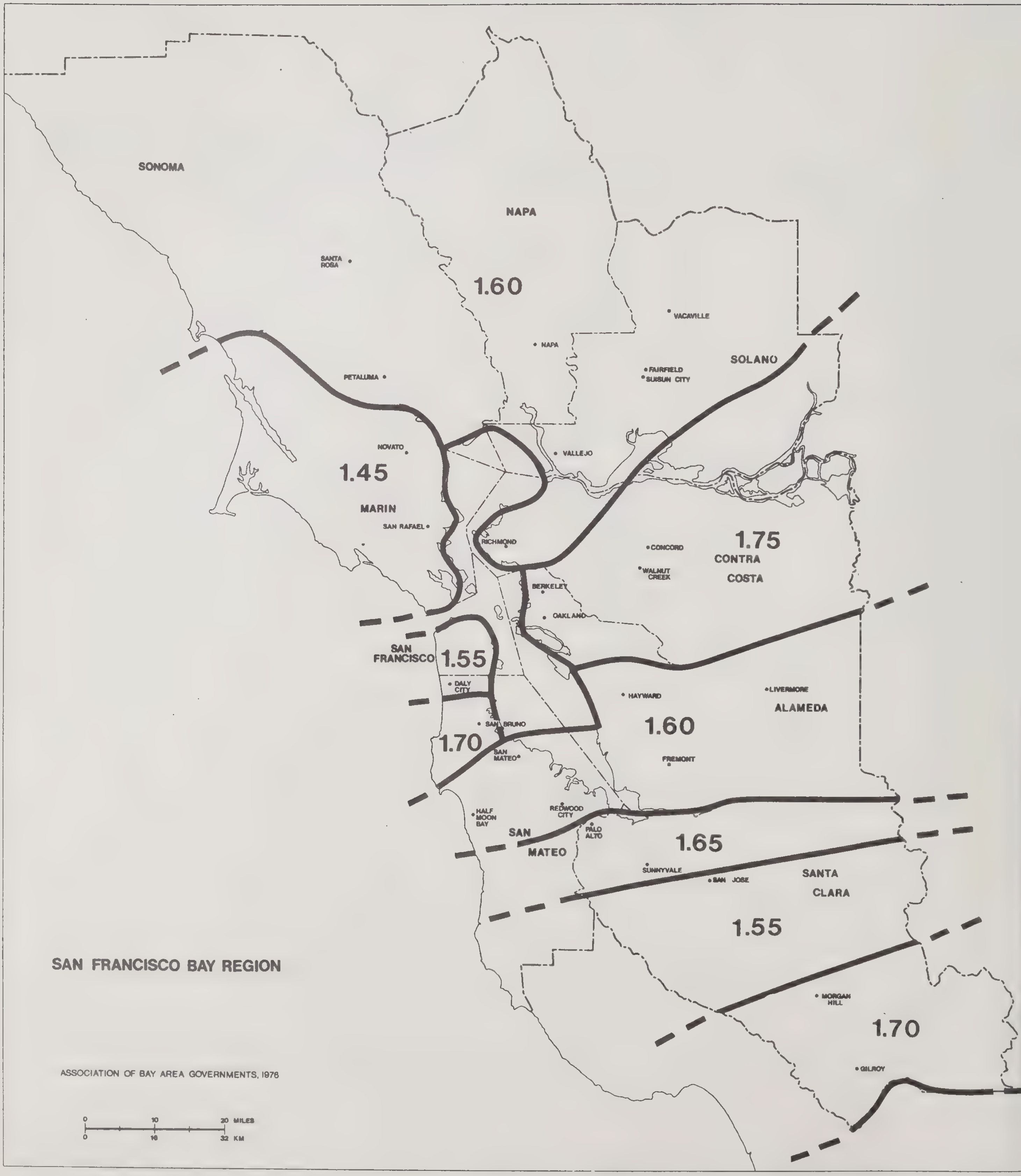
Year: 1975

Unit: $\mu g/m^3$

Station	Cmax, 24-hr.	Number of Times > 100	Expected Annual Geometric Mean
Burlingame	125	3	38
Concord	172	10	36
Fremont	230	46	59
Gilroy	178	27	59
Livermore	256	128	88*
Napa	137	11	58
Oakland	192	31	57
Pittsburg	250	45	56
Redwood City	138	7	50
Richmond	222	23	44
San Francisco	129	7	53
San Jose	177	37	65*
San Rafael	121	3	43
Santa Rosa	138	5	37
Sunnyvale	136	6	44
Vallejo	218	46	62*

* Expected annual geometric mean exceeds California Standard = $60 \mu g/m^3$.

Table 5. Summary of estimations for Particulates



GEOGRAPHIC DISTRIBUTION OF STANDARD GEOMETRIC DEVIATION (Sg) VALUES FOR PARTICULATES.

3. The general equation for estimating the annual expected maximum concentration for all averaging times is:**

$$C_{max_j} = (m_{g_j}) \cdot (S_{g_j})^{z_j}, \text{ where},$$

(a) $C_{max,j}$ = the expected annual maximum jth-hour concentration, j = 1, 3, 8, 12, 24.

(b) z_j = the number of standard deviations from the geometric mean correspond to the jth-hour averaging time. In particular, with total expanded one-hour total time period of one year, the following z_j values are shown as follows:

Averaging time, j-hour	z_j
1	3.81
3	3.53
8	3.26
12	3.14
24	2.94

(c) S_{g_j} = the standard geometric deviation for the jth-hour averaging time and is obtained through the following relationship:

$$S_{g_j} = (S_{g_1})\sqrt{1 - \frac{\ln t_j}{9.07795}}$$

where t_j = the jth-hour averaging time (in hours), and

S_{g_1} = the estimated standard geometric deviation for the one-hour averaging time, and its estimation is explained in the next step.

(d) The model parameter, $Sg = e^{\sigma}$ is usually unknown, and an estimate from sampled data can be obtained by the following empirical relationship:

$$S_{g_1} = e^{z_0 - \sqrt{z_0^2 - 2\ln\left(\frac{c}{m}\right)}},$$

where C = the observed maximum 1-hour concentration,
m = the arithmetic mean concentration,
z_0 = the number of standard deviations of the observed maximum 1-hour concentration is from the sampled median concentration. The value of z_0 is obtained by evaluating the following plotting frequency formula:

$$f = \frac{r - 0.4}{n}(100\%)$$

**see ref. (1) for details of the Larson Model equations.

where f = the plotting position frequency corresponds to the area under the standard normal probability distribution to the right of cut-off point z_0 and z_0 can be obtained from the standard normal probability table.

r = the rank order of the observed maximum concentration, and

n = the observed sample size.

If the maximum observed value occurs more than once, say k times, the median rank $r = \frac{1}{2}(k+1)$ is used.

(e) m_{g_j} = the geometric mean of the jth-hour distribution and can be estimated by the empirical relationship:

$$m_{g_j} = m \cdot (m_{g_1}/m)^{1-\frac{\ln t_j}{9.07795}},$$

where m, t_j are previously defined, and m_{g_1} is the 1-hour geometric mean and can be estimated from sample statistics S_{g_1}, C, and z_0 as follows:

$$m_{g_1} = C \cdot S_{g_1}^{-z_0}$$

4. Alternatively, a graphical procedure of the Model is applied (if needed). The two parameter lognormal distribution can be represented by a straight line on a log-probability graph paper. Plotting the base year observed values versus the relative more than cumulative frequency in percentage on a log-probability graph paper, then draw a best fit line through the top 50th percents of the data, then estimated statistics such as the geometric mean, standard geometric deviation, and expected maximum concentration can be obtained from the fitted line on the graph. The geometric mean is the value that corresponds to the 50th percentile, and the standard geometric deviation is the ratio of the 16th percentitle value to the 50th percentile on the graph. The annual expected maximum concentration is the value that corresponds to the percentile representing a frequency of occurrence of once a year. Once the base year (1975) one-hour geometric mean, standard geometric deviation, and annual maximum concentration are obtained, then the calculations for other averaging times can be computed using equations in Step 3 above.

5. To calculate the number of times exceeded ambient air quality standard for all averaging times, the following probability concept is used:

$$N = n \cdot P(C \geq s+1),$$

where N = the number of times ambient air quality exceeded standards, s,

s = Air quality standard,

n = the expanded sample size,

C = concentration, and

$P(C \geq S+1)$ = the probability of the event that ambient pollutant concentration greater than the air quality standard;

$$= \int_{S+1}^{\infty} f(c;\mu,\sigma)\,dc,$$

where $f(c;\mu,\sigma)$ is the lognormal probability density function as stated in Section 1.

Practically, the probability statement can be solved by transforming the lognormal into the standard normal distribution by:

$$Z = \frac{\ln(c/Mg)}{\ln Sg}$$

The result is:

$P(C \geq S+1) = P(Z \geq z')$, and then find the area greater than the value $z' = \frac{\ln(S+1/Mg)}{\ln Sg}$ from the standard normal distribution table.

Analysis of Basic Model Assumption

The main assumption of the Model is the lognormal distribution in characterizing the pollutant concentrations. Although it is generally accepted (and can be shown by theoretical and empirical results) that the lognormal distribution approximates the pollutant concentration frequency distribution well, we must however examine its validity for the Bay Area.

In evaluating the correctness of the lognormal assumption for each case, the following procedures were employed:

(a) By examining the "goodness of fit" of a straight line on the observed measurements plotted on a lognormal probability paper. If a "free-hand" straight line fits well, then the lognormal assumption is acceptable, otherwise, it is not.

(b) To compare numerically by observing the closeness of the absolute values of the following statistics:

$$|Sg^{(1)} - Sg^{(2)}| \text{ and } |Mg^{(1)} - Mg^{(2)}|$$

where $Sg^{(1)} = \exp\left(\sqrt{\ln\left(\frac{s}{m}\right)^2 + 1}\right)$ and

$Mg^{(1)} = m/\exp(.5\ln^2 Sg^{(1)}),$

where s = the standard arithmetic deviation,

m = the arithmetic mean

These two statistics are calculated from all observed data.

$Sg^{(2)} = \exp(z_0^2 - \sqrt{z_0^2 - 2\ln(\frac{c}{m})})$ $\qquad$ $Mg^{(2)} = c / Sg^{(2)z_0}$

These two statistics are obtained as described in Section 3; they are calculated from the maximum observed value and arithmetic mean. $Sg^{(2)}$ and $Mg^{(2)}$ can also be estimated from the graphical method, whereas $Sg^{(2)}$ is the ratio of the 16 percentile value to the 50 percentile value and $Mg^{(2)}$ is equal to the 50 percentile value.

If the pollutant concentration frequency is lognormal, both absolute differences are small, while a large difference would be a sign of non-lognormality.

Results of the analysis:

1. For carbon monoxide, nitrogen dioxide, and particulate: each station in the Bay Area was examined by both procedures (a) and (b). Results showed that the lognormal distribution does approximate the pollutant concentration at all stations. Tables 6 to 8 show the results used by procedure (b). Results used by procedure (a) can be found in the Appendix.

2. For oxidant: most stations examined by both procedures showed that lognormality is acceptable. Using procedure (b) results seem to indicate that at six stations--Fairfield, Livermore, Napa, Petaluma, Pittsburg, and Concord--the lognormal assumption is questionable. However, using procedure (a), the line in the lognormal probability graph paper seemed to fit well at each station. Therefore, the lognormal assumption was presumed valid. Table 9 shows the comparisons used by procedure (b). Procedure (a) results can be found in the Appendix.

3. For sulfur dioxide, there are only eight stations which contained sufficient observed concentration values. For these eight stations, the observed values are very low (most observed values are between 0 and 3 pphm). Using procedures (a) and (b), Table 10 shows the results using procedure (b). Five stations--Concord, Napa, Crockett, Pittsburg, and Richmond--show lognormality is acceptable; whereas, the other three--Benicia, Martinez and Santa Rosa--show lognormality is definitely not acceptable.

E. Conclusion

Applying the Larsen statistical model, we have estimated:

(1) the base year, 1975, annual expected maximum concentrations for carbon monoxide, nitrogen dioxide, particulate, oxidant, and sulfur dioxide;

(2) the expected annual averages for nitrogen dioxide, sulfur dioxide, and particulate pollutants;

Table 6. Comparisons of standard geometric deviations and geometric means for carbon monoxide concentrations (ppm).

Station	Sg(1)[a]	Sg(2)[b]	|Sg(1)-Sg(2)|	Mg(1)[a]	Mg(2)[b]	|Mg(1)-Mg(2)|
Burlingame	1.7	1.65	.05	3.1	3.2	.10
Concord	1.5	1.60	.10	2.6	2.5	.10
Fremont	1.8	1.62	.18	1.6	1.6	0
Gilroy	1.5	1.54	.04	2.1	2.1	0
Livermore	1.8	1.80	0	1.8	1.8	0
Napa	1.5	1.50	0	2.5	2.5	0
Oakland	2.0	1.90	.10	1.4	1.5	.10
Pittsburg	1.6	1.78	.18	1.4	1.4	0
Redwood City	1.9	1.90	0	2.0	2.0	0
Richmond	1.6	1.60	0	1.9	1.9	0
San Francisco	2.0	2.30	.30	1.5	1.3	.20
San Jose	1.9	1.90	0	2.0	2.1	.10
San Rafael	1.7	1.60	.10	2.5	2.6	.10
Santa Rosa	1.5	1.55	.05	2.7	2.6	.10
Sunnyvale	1.8	1.84	.04	1.8	1.8	0
Vallejo	1.7	1.70	0	2.4	2.4	0

[a] $Sg(1) = \exp\left(\sqrt{\ln\left(\left(\frac{S'}{m}\right)^2 + 1\right)}\right)$ and

$Mg(1) = m / \exp\left(\frac{1}{2}\ln^2 Sg(1)\right)$.

[b] $Sg(2) = \exp\left(\frac{z}{z_0} - \sqrt{\left(\frac{z}{z_c}\right)^2 - 2\ln\left(\frac{c}{m}\right)}\right)$ and

$Mg(2) = C \cdot Sg(2)^{-z/z_0}$.

Table 7. Comparisons of standard geometric deviations and geometric means for nitrogen dioxide concentrations (ppm)

Station	Sg(1)[a]	Sg(2)[b]	|Sg(1)-Sg(1)|	Mg(1)[a]	Mg(2)[b]	|Mg(1)-Mg(2)|
Burlingame	2.6	2.0	0.6	.010	.013	.003
Concord	2.0	1.8	0.2	.023	.025	.002
Fremont	2.0	1.9	0.1	.030	.031	.001
Gilroy	1.8	1.9	0.1	.016	.015	.001
Livermore	1.8	1.7	0.1	.025	.027	.002
Napa	1.8	1.6	0.2	.023	.021	.002
Oakland	2.1	1.9	0.2	.021	.020	.001
Pittsburg	2.1	1.8	0.3	.018	.019	.001
Redwood City	2.1	1.9	0.2	.030	.030	0
Richmond	1.9	1.8	0.1	.026	.020	.006
San Francisco	1.6	1.6	0	.029	.028	.001
San Jose	1.8	1.8	0	.034	.034	0
San Rafael	1.7	1.6	0.1	.026	.027	.001
Santa Rosa	1.8	1.8	0	.018	.019	.001
Sunnyvale	1.8	1.8	0	.034	.034	0
Vallejo	2.0	1.8	0.2	.019	.019	0

[a] $Sg(1) = \exp\left(\sqrt{\ln\left(\frac{S'}{m}\right)^2+1}\right)$, and
$Mg(1) = m/\exp\left(.5 \ln^2 Sg(1)\right)$.

[b] $Sg(2) = 16\%/50\%$ value, and
$Mg(2) = 50\%$ value.

Table 8. Comparisons of standard geometric deviations for particulate concentrations ($\mu g/m^3$)

Station	Sg(1)[a]	Sg(2)[b]	|Sg(1)-Sg(2)|
Burlingame	1.7	1.47	.23
Concord	1.8	1.72	.08
Fremont	1.7	1.61	.09
Gilroy	1.6	1.47	.13
Livermore	1.7	1.43	.23
Napa	1.5	1.36	.14
Oakland	1.6	1.53	.07
Pittsburg	1.8	1.66	.14
Redwood City	1.6	1.42	.18
Richmond	1.6	1.66	.06
San Francisco	1.5	1.38	.12
San Jose	1.5	1.43	.07
San Rafael	1.5	1.40	.10
Santa Rosa	1.6	1.57	.03
Sunnyvale	1.6	1.48	.12
Vallejo	1.6	1.53	.07

a $Sg(1) = \exp\left(\sqrt{\ln\left(\frac{s'}{m}\right)^2 + 1}\right)$

b Sg(2) = 16%/50% value

Table 9. Comparisons of standard geometric deviations and geometric means for oxidant concentrations (pphms)

Station	Sg(1)[a]	Sg(2)[b]	|Sg(1)-Sg(2)|	Mg(1)[a]	Mg(2)[b]	|Mg(1)-Mg(2)|
Concord	2.9	1.9	1.0	1.0	1.3	0.3
Fairfield	2.9	1.6	1.3	1.4	1.9	0.5
Fremont	2.6	2.0	0.6	1.3	1.5	0.2
Gilroy	2.8	1.9	0.9	1.1	1.4	0.3
Hayward	2.3	1.9	0.4	2.0	2.1	0.1
Livermore	2.9	1.8	1.1	1.3	1.8	0.5
Los Gatos	2.0	1.8	0.2	1.6	1.7	0.1
Mt. View	1.9	2.0	0.1	1.6	1.6	0
Napa	3.0	1.9	1.1	1.2	1.6	0.4
Oakland	2.2	1.7	0.5	1.2	1.3	0.1
Petaluma	2.7	1.7	1.0	1.2	1.5	0.3
Pittsburg	2.8	1.7	1.1	1.1	1.5	0.4
Redwood City	2.7	1.8	0.9	1.2	1.4	0.2
Richmond	2.6	1.8	0.8	0.9	1.1	0.2
San Francisco	1.9	1.5	0.4	1.1	1.2	0.2
San Jose	2.2	1.9	0.3	1.7	1.8	0.1
San Leandro	2.5	1.7	0.8	1.7	2.0	0.3
San Rafael	2.5	2.3	0.2	0.6	0.6	0
Santa Rosa	2.6	1.7	0.9	1.1	1.3	0.2
Sunnyvale	1.9	2.0	0.1	1.7	1.7	0

[a] $Sg(1) = \exp\left(\sqrt{\ln\left(\frac{s'}{m}\right)^2+1}\right)$ and
$Mg(1) = m/\exp\left(\frac{1}{2}\ln^2 S_{g(1)}\right)$.

[b] $Sg(2) = \exp\left(z_0 - \sqrt{z_0^2 - 2\ln\left(\frac{c}{m}\right)}\right)$, and
$Mg(2) = c/S_{g(2)}^{z_0}$

Table 10. Comparisons of standard geometric deviations and geometric means for sulfur dioxide concentrations (pphm).

Station	$Sg^{(1)}$ [a]	$Sg^{(2)}$ [b]	$Sg^{(1)}-Sg^{(2)}$	$Mg^{(1)}$ [a]	$Mg^{(2)}$ [b]	$Mg^{(1)}-Mg^{(2)}$
Benicia	1.5	4.40	2.90	.30	.03	.27
Concord	2.3	2.37	.07	.40	.35	.05
Crockett	3.1	3.54	.44	.60	.50	.15
Martinez	1.9	4.06	2.66	.30	.11	.19
Napa	2.0	2.0	0	.40	.63	.23
Pittsburg	2.4	2.36	.04	.60	.55	.05
Richmond	2.2	3.10	.90	.30	.21	.09
Santa Rosa	1.1	7.8	6.70	.30	.001	.299

[a] $Sg^{(1)} = \exp\left(\sqrt{\ln\left(\frac{S'}{m}\right)^2+1}\right)$ and

$Mg^{(1)} = m / \exp\left(\frac{1}{2} \ln^2 S_g^{(1)}\right)$.

[b] $Sg^{(2)} = \exp\left(z_0 - \sqrt{z_0^2 - 2\ln\left(\frac{c}{m}\right)}\right)$ and

$Mg^{(2)} = c / S_g^{(2)\, z_0}$.

(3) the number of times greater than standard for various appropriate averaging times for each pollutant.

In addition, we have illustrated that the lognormality assumption in the Larsen Model was quite acceptable except in a very few cases. Therefore, the results obtained are reliable and suitable as a basis for forecasting using the Rollback methodology.

Application of the EPA Ozone Isopleth Method to the San Francisco Bay Region

The Environmental Protection Agency (EPA) has developed a new method for relating maximum ozone (O_3) concentrations to emissions of non-methane hydrocarbons (NMHC) and oxides of nitrogen (NO_x). The ozone isopleth method is an approach to estimate the degree of organic and/or NO_x controls required to achieve the oxidant standard. In essence this method utilizes a set of simulated ozone curves relating the sensitivity of maximum hourly afternoon ozone to changes in NMHC and NO_x under meteorological conditions conducive to oxidant formulation. The following two draft publications by E.P.A., Research Triangle Park, N.C. March 1977, contain a full description of the method, its development, and usages:

(i) "Policy statement - acceptable replacements for Appendix J procedures for determining the degree of control needed to attain national photochemical oxidants standard," and

(ii) "Alternatives for estimating the effectiveness of State Implementation Plans for oxidant."

Since the ozone isopleth method is an alternative modeling procedure which can be used to estimate the control needed to attain the oxidant standard, the following is an attempt to apply this method to the Bay Area for the year 1975.

Data Development

The San Francisco Bay Area is a large and complex region which contains many urban core stations. Our first effort is to select the most appropriate and representative sets of precursor and oxidant station combinations to which the isopleth method could be applied. If results after applying the method are shown to be sound and reasonable, other combinations of precursor and oxidant stations would be selected and tried.

The selected precursor stations are San Francisco and San Jose, and the oxidant stations are San Jose and Livermore. Therefore, four basic combinations are established and listed as follows:

Precursor Station	Oxidant Station
San Francisco	Livermore, San Jose
San Jose	Livermore, San Jose

These four stations combinations were selected by staff experts at the Bay Area Air Pollution Control District (BAAPCD).[1] The basis for the

[1]Messrs. Jim Sandberg and Rob DeMandel.

selection of San Francisco as a precursor station was that it is an ideal upwind station for the whole region and particularly for downwind oxidant stations of San Jose and Livermore. The reasons for selecting San Jose as a precursor station was that San Jose itself is a large urban core station and an upwind station for Livermore and San Jose southern section. During morning hours, especially on smoggy days, primary pollutants drift northward toward Livermore area and later in the day, they are brought back over the Santa Clara Valley by afternoon sea breezes.

Two basic sets of data are then measured from these selected stations. From the precursor stations of San Francisco and San Jose, 6-9 a.m. concentrations of NMHC and NO_x were measured from original strip charts recorded by the BAAPCD for the months of June and September, 1975. June and September months are used because they contained the highest observed oxidant days during the oxidant season, June-November period. Measured data of NMHC and NO_x are needed for calculating the NMHC/NO_x percentile values, the basic information required to apply the isopleth method. From the oxidant stations of Livermore and San Jose, highest hourly average oxidant concentrations for each station were obtained from BAAPCD records. This additional set of data was needed to evaluate the reliability of the presumed source (precursor) and receptor (oxidant) relationship.

<u>Calculations of NMHC/NOx Percentiles</u>

Two basic pieces of information are needed to apply the isopleth method. They are the highest observed afternoon hourly oxidant concentration and the prevailing median NMHC/NO_x ratio values at the 6-9 a.m. period. The highest observed afternoon hourly oxidant concentrations were obtained by inspection from BAAPCD 1975 records. The NMHC/NO_x ratio values were estimated for each of the San Francisco and San Jose precursor stations through the following steps:

(1) Calculate the daily mean 6-9 a.m. concentrations of NMHC and NO_x;

(2) Divide each mean value of NMHC by mean value of NO_x; the result is a set of daily mean 6-9 a.m. ratio values of NMHC/NO_x;

(3) Construct a less than cumulative relative (%) frequency curve of NMHC/NO_x values; and finally

(4) Estimate the 10, 50, 90th percentile values from the cumulative frequency curve.

Figure 1 shows the cumulative frequency curve for San Francisco and San Jose stations and their various estimated percentile values. In summary, the estimated 6-9 a.m. mean NMHC/NO_x percentile values were recorded as follows:

Precursor Station	NMHC/NO_x Percentiles 10	50	90
San Francisco	0.20	1.20	3.80
San Jose	0.40	1.70	3.20

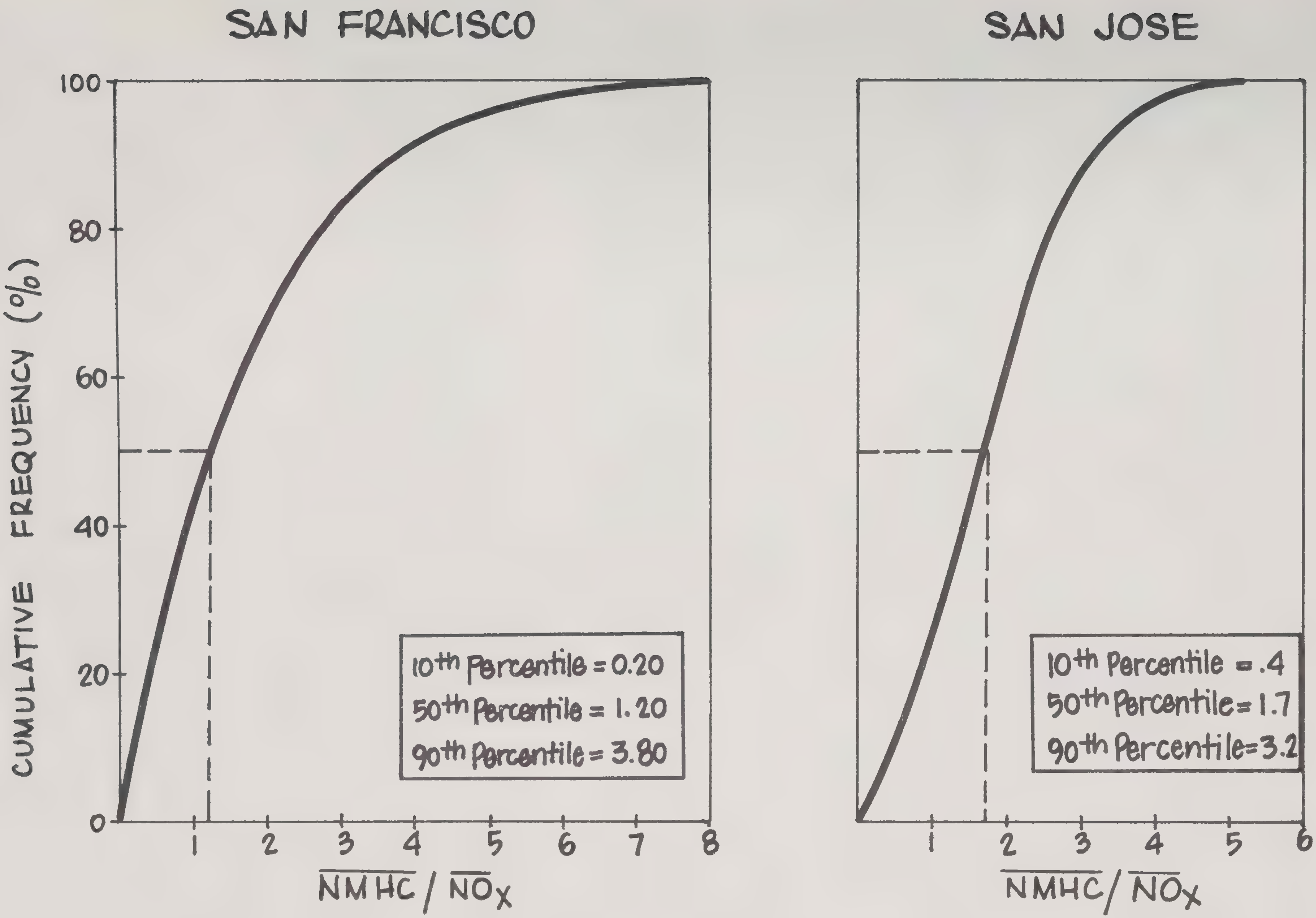


Figure 1. Cumulative frequency curves for San Francisco and San Jose precursor stations and estimated 10, 50, 90th percentile values.

Source/Receptor Relationship

One of the basic assumption of the isopleth method is the existence of a direct relationship between the source (precursor) values and receptor (oxidant) values. It seems appropriate to evaluate the validity of this basic assumption before applying the isopleth method. Simple regression analysis was performed between 6-9 a.m. mean $NMHC/NO_x$ ratio values at the precursor station and daily maximum hourly average oxidant concentrations observed at the ozone station for each precursor/oxidant station combination. Figure 2 shows the scatter diagram and the estimated regression line for each case. The following table lists the correlation coefficients for the four precursor/oxidant station combinations:

Precursor Station	Oxidant Station	Correlation Coefficient
San Francisco	Livermore	.073
San Francisco	San Jose	.316
San Jose	Livermore	.218
San Jose	San Jose	.381

The scatter of the measured values around the regression lines and the low values of the correlation coefficients indicates a poor relationship between the source values and oxidant values for all cases. This implies that the relationship between the precursor and ozone data is quite weak for each case.

Ozone Isopleth Method Application

In applying this method, we would need to construct a line with the median $NMHC/NO_x$ ratio value drawn on the ozone isopleths diagram. Figure 3 shows such a diagram derived by EPA. Our estimated median $NMHC/NO_x$ ratio value is 1.2:1 for San Francisco and 1.70:1 for San Jose precursor station. With a ratio value of 1.2:1, we cannot construct a line on the ozone isopleths diagram for any given high hourly afternoon ozone value. Likewise for San Jose precursor station with median $NMHC/NO_x$ ratio 1.7:1. Therefore, our data show that the ozone isopleths method is not applicable for either San Francisco or San Jose precursor stations.

Conclusion

Effort has been directed to apply the E.P.A. ozone isopleth method to the most sound and logical sets of precursor/oxidant station combinations for the Bay Area. We found that the basic assumption of source/receptor relationships is weak. Therefore this assumption is in question. The median $NMHC/NO_x$ ratio values estimated for San Francisco and San Jose stations were 1.2:1 and 1.7:2, respectively, and it was not possible to construct a line corresponding to the maximum hourly O_3 on the ozone isopleth diagram. Therefore, we conclude that the isopleth method is not applicable to the Bay Area for the year 1975.

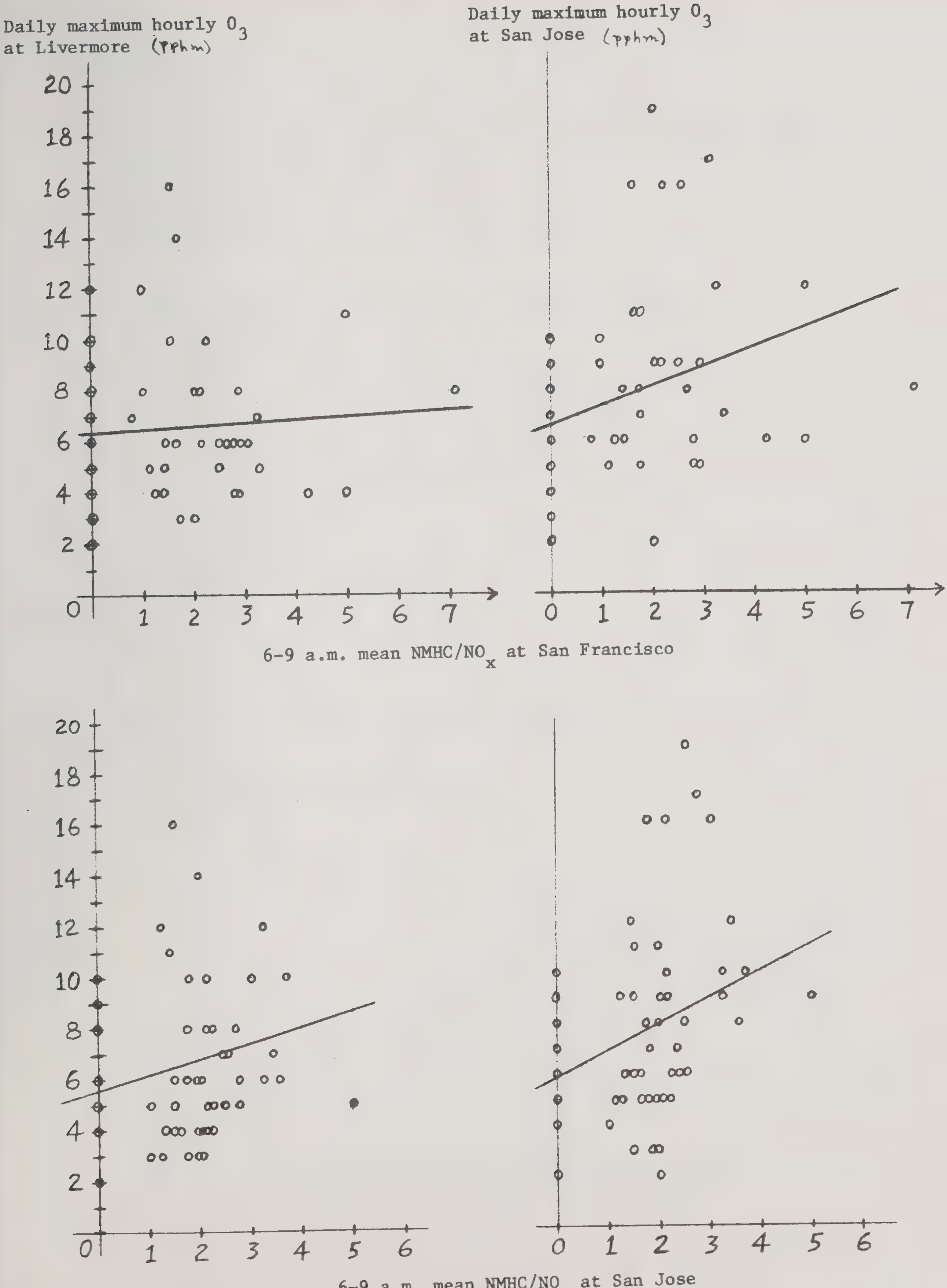


Figure 2. Scatter diagrams and regression lines.

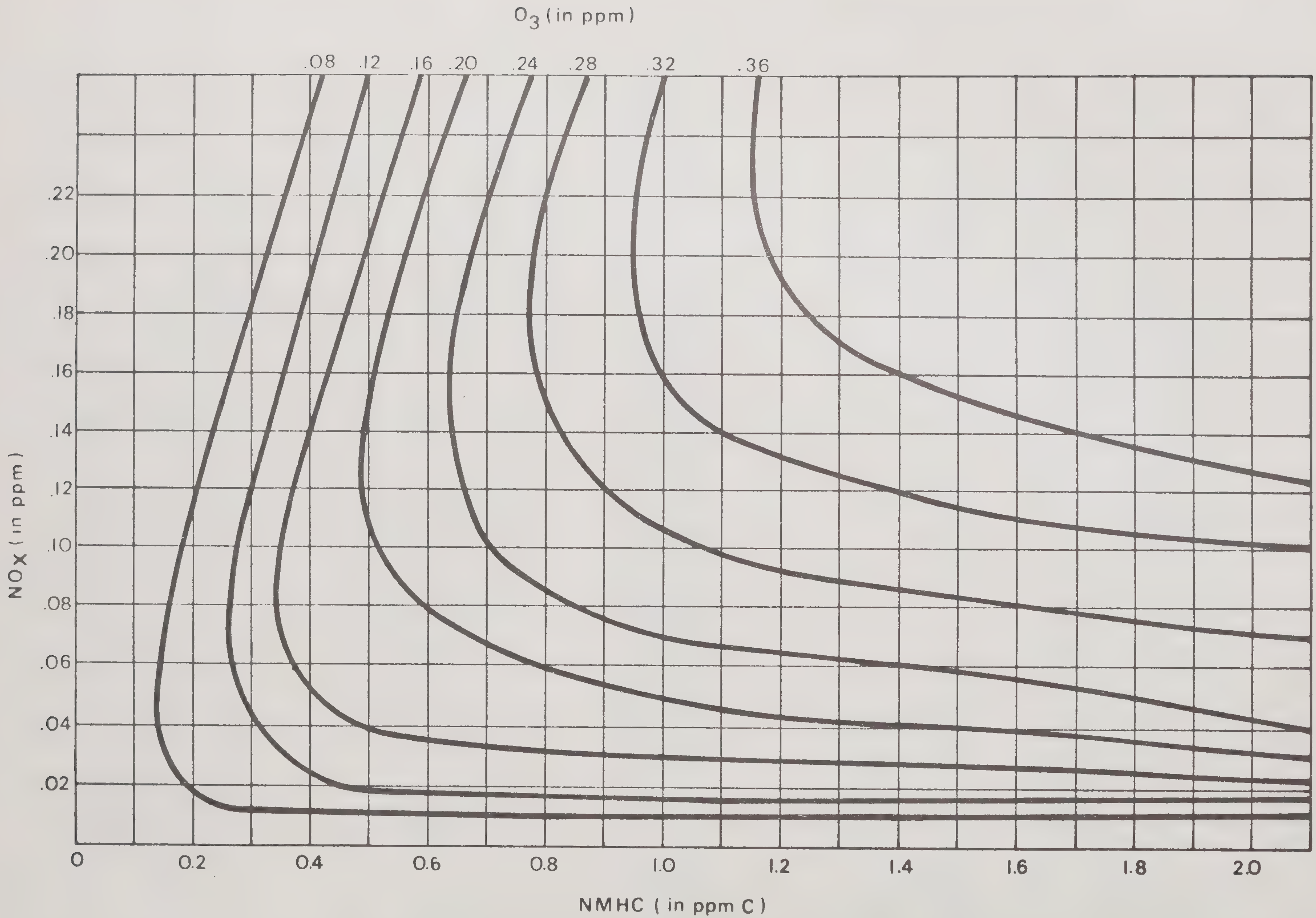


Figure 3. Ozone Isopleths Diagram

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AQMP Tech Memo 20 September 1977
R. Wada

PROCEDURE FOR INTERPRETATION OF LIRAQ AIR QUALITY PROJECTIONS

This technical memorandum documents the procedure used to interpret projections of future air quality produced by the Livermore Regional Air Quality Model (LIRAQ). Specifically, the interpretation of model forecasts with respect to the air quality standard for photochemical oxidants (0.08 ppm-1-hour) is addressed as a key aspect of AQMP development. AQMP/Issue Papers 1 and 2 included a review of alternative models and have raised important modeling issues for discussion. Those issues as well as others which have surfaced during the course of AQMP development may be summarized as follows:

- The "meteorological days" in the LIRAQ library are not the worst case days which have occurred in the Bay Area. Since the oxidant standard is defined as "not to be exceeded more than once per year", demonstrating oxidant levels at or below .08ppm on days which are not the worst or second worsts day does not necessarily demonstrate attainment of the oxidant standard.

- Since no model can be expected to precisely replicate conditions which occurred on a specific day, it may be expected that model validation results will not be perfect. Therefore, demonstrating oxidant levels at or below .08ppm on the simulated days will not necessarily demonstrate that attainment of the oxidant standard would occur on the actual days.

- Due primarily to limits of computer capacity, the area covered by the LIRAQ grid is somewhat limited. This creates two problems: First, in order to model oxidant in the Santa Clara and Livermore Valleys where the problem has historically been the worst, the grid does not include parts of the Bay Area north of Vallejo. Thus, most of the more sparsely populated northern counties of Marin, Napa, Sonoma, and Solano are omitted when analyzing the severe problem areas. Second, the effects of transport of pollutants generated within the region to other areas such as Sacramento, Stockton or Monterey cannot be immediately analyzed.

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*AQMP/Issue Paper 1, Air Quality Modeling for the San Francisco Bay Region," September 1976

AQMP/Issue Paper 2, The Air Quality Modeling Process: Accuracy and Related Issues," May 1977.

Discussion and resolution of these issues for the air quality maintenance plan has and continues to be the function of a special modeling committee. This committee is composed of modeling experts from a number of organizations participating in the AQMP: Bay Area Air Pollution Control District, Lawrence Livermore Laboratory, California Air Resources Board, California Department of Transportation, Environmental Protection Agency, Metropolitan Transportation Commission, Systems Applications, Inc. (a private modeling consultant), and the Association of Bay Area Governments. The following sections describe the procedures developed to address each of the issues described.

The "Worst Case" Issue

Problems and perspectives associated with the worst case issue have been discussed in AQMP Issue Paper 2. Four alternative procedures for obtaining a worst case estimate were outlined and presented to the AQMP Advisory Committee. The procedure selected for use in the AQMP involves a straightforward application of the Larsen model to relate the days in the LIRAQ library to the worst days recorded for a given year. Using the daily regionwide high hour oxidant measurement to characterize each day, the distribution of days for each historical year may be developed in the standard Larsen format. The frequency distributions thus developed are summarized in Appendix A. The log normal assumption was found to be quite satisfactory for this particular application, which is consistent with the evaluation of the Larsen model described in AQMP Tech Memo 19.

The net result of the Larsen "extrapolation" of LIRAQ results is summarized as follows:

Meteorological Day	Regionwide High Hour Oxidant Measurement	Expected Max. For That Year	Percent Extrapolation
July 26, 1973	.18ppm	.24ppm	33%
July 24, 1974	.20ppm	.24 ppm	20%
July 25, 1975	(data currently being developed)		

This means that, for example, on July 26, 1973 the high hour oxidant measurement was .18ppm, while the maximum hourly concentration for 1973 was .24ppm (confirmed by the Larsen model). Therefore, in order to obtain an estimate of expected worst hour oxidant levels in future years, the regionwide high hour forecast by LIRAQ under July 26, 1973 meteorological conditions should be increased by 33 percent. If LIRAQ forecasts that with a given control strategy and July , 1973 meteorology the regionwide high hour oxidant level is .06ppm, then the 33% extrapolation would yield .08ppm as the estimated worst hour concentration. This would also mean that the control strategy being tested would result in attainment of the oxidant standard.

This method of extrapolating LIRAQ results is reasonable provided that the magnitude of the extrapolation is small. Generally speaking, long range extrapolations are risky, and in the case of LIRAQ would lead to artificial conclusions regarding control requirements for attainment of the oxidant standard. Subjectively, extrapolations greater than 50 percent would be outside the range of reasonable application of this technique.

The Imperfect Validation

When a model is tested against measurements the procedure is called validation. Since models invariably contain simplifications and approximations of what happens in reality, it may be expected that model predictions will never perfectly replicate measurements. (Even measurements have uncertainty.)

In order to overcome this problem, a procedure for computing an adjustment factor was developed. The formula for the adjustment factor is as follows:

$$\frac{C_f}{C_v} = \frac{C_s}{C_m} \qquad \text{or} \qquad C_s = \frac{C_m}{C_v} \cdot C_f$$

where C_m = regionwide high hour oxidant concentration measured on the validation day

C_v = regionwide high hour oxidant concentration reproduced by the model on the validation day

C_f = regionwide high hour oxidant concentration forecasted by the model under some future emission scenario

C_s = regionwide high hour oxidant concentration to be computed and compared to the oxidant standard

In other words, the ratio of the measured regionwide high hour oxidant concentration on a given validation day to the model-produced regionwide high hour oxidant concentration is used to adjust forecasted oxidant maxima. This compensates the forecast for any inherent biases in the model or input data. For example, on July 26, 1973 the measured oxidant maximum was .18ppm at Livermore, while the model-produced maximum was .17ppm at a location roughly 10 kilometers south-southeast of Livermore. The adjustment ratio is therefore .18/.17 = 1.06. The use of model-produced values at nearby locations is consistent with the use of the ratio adjustment--the need for the ratio development in the first place is because of expected imperfections in the model and/or input data. To compute the adjustment ratio using modeled data and measured data at the same location would be inconsistent in that the model would be assumed to be imperfect in forecasting <u>magnitude</u> but perfect in forecasting <u>location</u> of the oxidant maximum.

As was stated previously with regard to the worst case issue, this procedure is reasonable provided that the magnitude of the adjustment is small. No adjustment factor can be expected to adequately compensate for major deficiencies in either model formulation or input data base. The small magnitude of the adjustment for July 26, 1973 is indicative of good model performance.

Limitations of LIRAQ Grid Coverage

Of the two problems created by the limited LIRAQ coverage, one is easily surmounted while the other cannot be resolved within current schedule and analysis constraints. Air quality in the northernmost counties of the Bay Area can be evaluated by shifting the analysis grid such that major emission sources affecting air quality in the north are still included. Since severe oxidant days generally do not involve transport of pollutants from the extreme south to the extreme north of the Bay Region (or vice versa), the grid can be shifted without significant affect on the validity of the analyses. In addition, a meterological day which resulted in poor air quality in the north (July 25, 1975) is being added to the LIRAQ library for future analyses.

The problem of long-range transport of pollutants out of the region cannot be overcome by a simple shifting of the LIRAQ grid. Because of the relatively great distances of concern, it is not possible to shift the grid without losing major emission sources in the process. Expansion of the grid is limited primarily because the size of the grid required to cover the distances of interest would be such that existing computers would not be of sufficient capacity to handle the calculations. The analysis of long-range transport problems is currently a research problem for which models are being developed.

APPENDIX A

LARSEN FREQUENCY DISTRIBUTIONS FOR WORST CASE EXTRAPOLATION

OXIDANTS-73

OXIDANTS-73

ARITHMETIC MEAN = 3.367
STANDARD ARITHMETIC DEVIATIN = 2.223

RANGE IS .0000 TO 24.00
MEDIAN = 2.00

SAMPLE SIZE = 7370

FREQUENCY DISTRIBUTION

MBE: OC\C		FREQUENCY OF OCCURRENCE (%)	CUMULATIVE FREQUENCY % =OR<	LARSEN'S SAMPLE PLOTTING FREQUENCY % =OR>	NU
.0	.00--	.040	.040	99.978	3
.0	1.00--	7.550	7.590	96.186	556
.0	2.00--	39.700	47.290	72.563	2926
.0	3.00--	19.260	66.550	42.969	1419
.0	4.00--	12.300	78.850	27.188	907
.0	5.00--	6.790	85.640	17.643	500
.0	6.00--	7.480	93.120	10.512	551
.0	7.00--	1.750	94.870	5.899	129
.0	8.00--	1.270	96.140	4.386	94
.0	9.00--	.940	97.080	3.280	69
.0	10.00--	1.350	98.430	2.141	99
.0	11.00--	.360	98.790	1.286	27
.0	12.00--	.200	98.990	1.001	15
.0	13.00--	.250	99.240	.777	18
.0	14.00--	.250	99.490	.533	18
.0	15.00--	.140	99.630	.343	10
.0	16.00--	.120	99.750	.214	9
.0	17.00--	.040	99.790	.132	3
.0	18.00--	.040	99.830	.092	3
.0	20.00--	.010	99.840	.065	1
.0	21.00--	.010	99.850	.051	1
.0	22.00--	.020	99.870	.037	1
.0	24.00--	.010	99.880	.008	1

STATISTICAL PARAMETERS FROM 1-HOUR AVERAGING TIME DATA

ARITHMETIC MEAN = 3.367
STANDARD DEVIATION = 2.223

MONITORED SAMPLE SIZE = 7370 HOURS
EXPANDED SAMPLE SIZE = 8030 HOURS

FROM MAXIMUM OBSERVED VALUE AND ARITHMETIC MEAN:

STANDARD GEOMETRIC DEVIATION = 1.756
GEOMETRIC MEAN = 2.874

EXPECTED MAXIMUM 1-HOUR CONCENTRATION
FROM SAMPLING PARAMETERS = 24.29 PPHM

NUMBER OF TIMES AMBIENT AIR QUALITY
STANDARD OF 8.00 PPHM TO BE EXCEEDED = 275
TIMES DURING THE EXPANDED SAMPLING PERIOD

PREDICTED LARSENS FREQUENCIES FOR 1-HOUR CONCENTRATION
S

CONCENTRATION PPHM	LARSENS FREQUENCY % =OR>
1.00	96.9663
2.00	74.0315
3.00	46.9672
4.00	27.8523
5.00	16.2631
6.00	9.5497
7.00	5.6878
8.00	3.4472
9.00	2.1277
10.00	1.3371
11.00	.8549
12.00	.5555
13.00	.3666
14.00	.2454
15.00	.1664
16.00	.1143
17.00	.0794
18.00	.0558
19.00	.0396
20.00	.0284
21.00	.0205
22.00	.0150
23.00	.0110
24.00	.0081

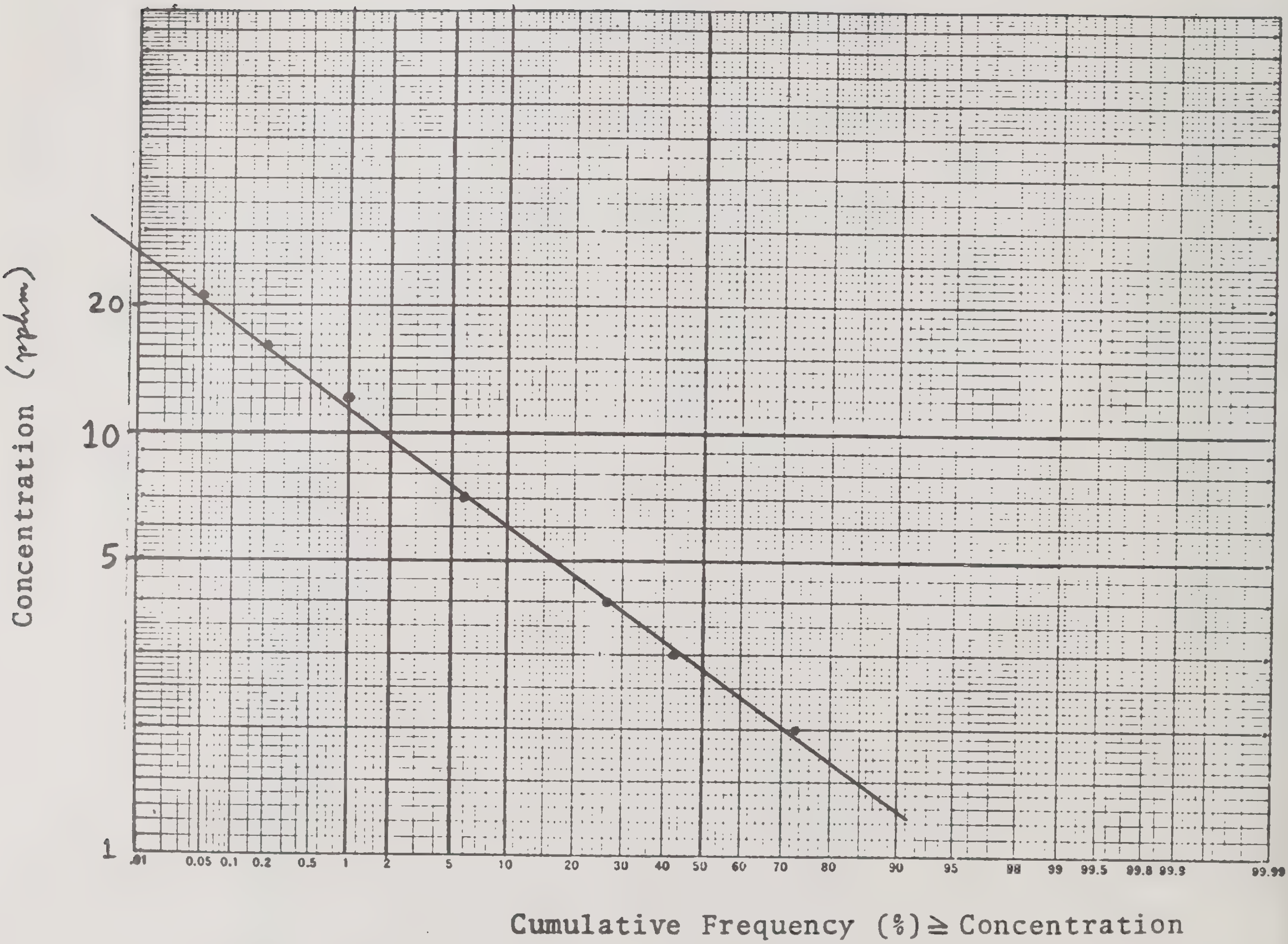
FROM ALL OBSERVED DATA:

STANDARD GEOMETRIC DEVIATION = 1.825
GEOMETRIC MEAN = 2.811

Pollutant : OXIDANTS Year: 1973

Location: S.F. BAY AREA Averaging Time: 1-Hr.

Unit: pphm



M_g = 2.87

S_g = 1.76

C_{max} = 24.3

STATISTICAL PARAMETERS FROM 1-HOUR AVERAGING TIME DATA

ARITHMETIC MEAN = 3.973
STANDARD DEVIATION = 2.131

MONITORED SAMPLE SIZE = 8567 HOURS
EXPANDED SAMPLE SIZE = 9125 HOURS

FROM MAXIMUM OBSERVED VALUE AND ARITHMETIC MEAN:

STANDARD GEOMETRIC DEVIATION = 1.653
GEOMETRIC MEAN = 3.501

EXPECTED MAXIMUM 1-HOUR CONCENTRATION
FROM SAMPLING PARAMETERS = 23.94 PPHM

NUMBER OF TIMES AMBIENT AIR QUALITY
STANDARD OF 8.00 PPHM TO BE EXCEEDED = 455
TIMES DURING THE EXPANDED SAMPLING PERIOD

PREDICTED LARSENS FREQUENCIES FOR 1-HOUR CONCENTRATIONS

CONCENTRATION PPHM	LARSENS FREQUENCY % =OR>
1.00	99.3656
2.00	86.7311
3.00	62.0701
4.00	39.5558
5.00	23.9261
6.00	14.2016
7.00	8.4116
8.00	5.0141
9.00	3.0207
10.00	1.8430
11.00	1.1397
12.00	.7144
13.00	.4539
14.00	.2921
15.00	.1903
16.00	.1255
17.00	.0837
18.00	.0564
19.00	.0384
20.00	.0264
21.00	.0183
22.00	.0128
23.00	.0091
24.00	.0064

ALL CALCULATIONS REFERENCE AP-89

STATISTICAL PARAMETERS FROM 1-HOUR AVERAGING TIME DATA

ARITHMETIC MEAN = 3.943
STANDARD DEVIATION = 2.195

MONITORED SAMPLE SIZE = 8526 HOURS
EXPANDED SAMPLE SIZE = ---- HOURS

FROM MAXIMUM OBSERVED VALUE AND ARITHMETIC MEAN:

STANDARD GEOMETRIC DEVIATION = 1.681
GEOMETRIC MEAN = 3.445

EXPECTED MAXIMUM 1-HOUR CONCENTRATION
FROM SAMPLING PARAMETERS = 25.48 PPHM

NUMBER OF TIMES AMBIENT AIR QUALITY
STANDARD OF 8.00 PPHM TO BE EXCEEDED = 533
TIMES DURING THE EXPANDED SAMPLING PERIOD

PREDICTED LARSENS FREQUENCIES FOR 1-HOUR CONCENTRATIONS

CONCENTRATION PPHM	LARSENS FREQUENCY % =OR>
1.00	99.1366
2.00	85.2402
3.00	60.5013
4.00	38.6907
5.00	23.6717
6.00	14.2797
7.00	8.6198
8.00	5.2448
9.00	3.2281
10.00	2.0129
11.00	1.2724
12.00	.8152
13.00	.5293
14.00	.3480
15.00	.2316
16.00	.1560
17.00	.1062
18.00	.0730
19.00	.0507
20.00	.0356
21.00	.0252
22.00	.0179
23.00	.0129
24.00	.0093
25.00	.0068

ALL CALCULATIONS REFERENCE AP-89

AQMP Tech Memo 21
T. PERARDI
M. KIM

October 1977

GEOGRAPHICAL DISTRIBUTION OF EMISSIONS FROM NON-MAJOR POINT (AREA) SOURCES

INTRODUCTION

One Component of the regional emissions inventory is the category for non-major point sources labeled as "area sources" by the Annual Source Inventory of the Bay Area Air Pollution Control District (BAAPCD). These emissions are from stationary sources which individually emit less than 100 tons/year, or from off-highway mobile sources. Some of the sources included in this category are: domestic fuel combusion, dry cleaning, farming operations, accidental fires, vapor degreasers, gasoline stations, small plastics manufacturing, ships, utility engines, and lawnmowers.

The total pollutant contribution from the area sources is of major importance in the regional emissions inventory. Emissons in 1975 from non-major point sources comprise about 58% of total particulate, 39% of organics, 15% of nitrogen oxides, 6% of sulfur dioxide, and 8% of carbon monoxide emitted in the region.[1]

For AQMP air quality modeling purposes, the area source emissions must be distributed by Universal Transverse Mercator (UTM) grid square over the entire Bay Region. The LIRAQ model utilizes an emission inventory which is disaggregated to 1 km resolution.

The data may be aggregated, however, to produce a 5 km square inventory for photochemical modeling of larger areas. The area sources, together with major point sources, mobile sources and airports, constitute a complete emission inventory for LIRAQ model runs.

The simplest approach would be to distribute the emissions uniformly over the land area involved. A more sophisticated approach would be to distribute the emissions according to population, since only anthropogenic air pollution is being considered. A more accurate distribution can be achieved, however, if source activities can be correlated with some subgroup of population, or with categories of employment or land use.

1 Bay Area Air Pollution Control District, 1975 EMISSION INVENTORY SUMMARY REPORT, August, 1976.

Temporal distribution of the area sources is achieved through the use of special processor codes which are documented elsewhere.[2] The purpose of this paper is to describe the procedure and methodology used for the spatial distribution of the area sources.

CROSS - CLASSIFICATION ANALYSIS

Distribution of area sources for 1975, 1985 and 2000 into the grid system has been carried out utilizing a cross-classification analysis. The objective is to establish functional relationships between source categories and the land use characteristics where the sources originated. In this case area source emissions are associated with regional demographic and employment data from the Series 3 Projections compiled by the Association of Bay Area Governments (ABAG).[3]

Cross-classification is a technique in which the change in one variable can be measured when the changes in two or more variables are accounted for. Essentially, "n" independent variables are stratified into two (or more, say p) appropriate groups, creating a p x n-dimentional matrix. Observations on the dependent variables are then allocated to the various cells of the matrix, based on the known values of the several independent variables, and then averaged. Using this example, a matrix, such as the one shown in Table 1 can be constructed, indicating definite patterns in the relationships between source categories and Series III variables.

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2 Processor codes are subroutines to the LIRAQ model which transform basic data files to the appropriate form. For area sources the program converts tons/day into grams/sec by hour.

See MacCracken and Sauter, "Development of an Air Pollution Model for the San Francisco Bay Area", Vol. 2, Appendices, Lawrence Livermore Laboratory report UCRL-51920, October 1, 1975.

3 Association of Bay Area Governments, PROVISIONAL SERIES 3 PROJECTIONS; POPULATION, HOUSING, EMPLOYMENT AND LAND USES, March, 1977.

TABLE 1

A SAMPLE MATRIX FOR CROSS-CLASSIFICATION OF SOURCE CATEGORY, POPULATION AND EMPLOYMENT

Dependent Variables	Independent Variables Land Use Activites					
Source Category	Pop.	Mfg.	TUC	Ret.	Gov't - -	Total
Domestic Fuel Combustion	x*	-	-	-	-	100%
Dry Cleaning	-	-	-	x	-	100%
Degreasers	-	x	-	x	-	100%
--	x	-	x	x	-	-
--	-	-	-	-	-	-
Actual Distribution	-	-	-	-	-	-
Percentage	-	-	-	-	-	100%

*x = percentage value.

AREA SOURCES AND SERIES 3 PROJECTION DATA

The BAAPCD Source Inventory Section has designated 107 separate activity classifications for which air pollutant emissions are measured or calculated. Fifty-eight of these categories include some area source contributions for one or more pollutants; the remaining categories include only specific point sources of known location. Appendix A contains a listing of the 1-7 classifications with percentage distribtuion of point and area sources.

The Series 3 Projections published by ABAG includes data on population, land use, and employment compiled for 440 sub-regional "zones" which are aggregations of U.S. census tracts. The Series 3 parameters utilized for area source distribution were employment (18 categories) and number of dwelling units. A list of the 19 parameters is included in Appendix B.

This process requires an intermediate step to disaggregate the 440 zonal totals to appropriate 1 km grid squares in the Bay Region. Approximately 20,000 1-km grid squares cover the entire Bay Region including land areas, ridges, high terrain, rivers and bays. In order to distribute the area sources into appropriate grid squares, the already developed and developable land areas were separated from the other unpopulated land. For this task ABAG's land use maps for 1975 and 2000 were used to determine the developed and developable land areas. The land use map for 2000 was used for both 1985 and 2000 due to uncertainties of growth patterns. Population and employment data from Series 3 Projections for 1975 were distributed into 4700 grid sqaures, and for 1985 and 2000 into 5600 grid squares.

A cross-classification table was developed to distribute the 58 BAAPCD area source categories according to the 19 Series 3 parameter values. Some of the categories fell very nearly into one-to-one correspondence. For example, BAAPCD Source Inventory category No. 18 "Farming Operations" emissions can be distributed with Series 3 employment category P7 "AGRI" which includes Standard Industrial Classifications (SIC) 01 for agricultural production and services. Also BAAPCD No. 40 "Printing" can be distributed with Series 3 "MFG 1" which is printing, publishing and related industries.

Other BAAPCD classifications did not fit clearly with a single Series 3 parameter, so a multiple distribution formula was required of the form,

$$E_i = c_{i1}E_i + c_{i2}E_i + c_{i3}E_i + \ldots + c_{i24}E_i$$

or,

$$E_i = \sum_{j=1}^{24} c_{ij}E_i \quad \text{WHERE} \quad \sum_{j=1}^{24} c_{ij} = 1$$

where:

E_i = emission rate (tons/day, annual average) for the <u>area</u> sources in the BAAPCD source activity classification number i.

c_{ij}= distribution coefficient to specify the fraction of E_i to be distributed with Series 3 projection variable j. (Variables with j = 2 through 6 are not used, so c_{i2} through c_{i6} may be considered to be equal to zero. Thus, the total number of variables actually used is 19 rather than 24.)

The distribution coefficients, c_{ij} were assigned by BAAPCD engineers, based on their judgment and field experience with sources in the Bay Area. The coefficient values are compiled in Appendix C. In the ideal case, these distribution coefficients would be calculated through regression analysis based on experimental measurements. But in this complex and large-scale situation, actual measured data points are not sufficient to describe even a fraction of the model field. Regression analysis would require detailed and comprehensive measurement of all sources in a large number of grid squares. To make such a comprehensive inventory of all emissions in even a single urban grid square would be extremely difficult and costly.

A single pollutant, sulfur dioxide for example, may be emitted from sources in many different source activity classifications. The final formula for distributing all area source SO_2, therefore, may contain contributions from several BAAPCD classifications. The equations would be:

$$E_{\substack{area \\ SO_2}} = \sum_{j=1}^{24} \left(\sum_{i=1}^{88} c_{ij} E_i \right) \quad \text{AND} \quad E_{\substack{area \\ SO_2}} = \sum_{i=1}^{88} E_i$$

Where E_{area} is the total emission rate (Tons/day, annual average) for all sources of SO_2 in BAAPCD source inventory classifications 1 through 88. Classifications 89 through 107 are mobile sources, which are treated by a completely separate process (travel model and emissions model) for inclusion in the source inventory QSOR files.

The final result of the area source distribution process is a series of five formulae--one for each pollutant--to specify how the total area emission quantity is to be distributed over the Series 3 population data:

$$e_{x,y} = r_1 m_1 + r_2 m_2 + \ldots + r_{24} m_{24} = \sum_{j=1}^{24} r_j m_j$$

where:

$e_{x,y}$ = emission rate (in Tons/day) for a certain pollutant in a single grid square with UTM coordinates x and y.

r_j = per capita emission rate ($\frac{\text{Tons/day}}{\text{inhabitant}}$) for Series 3 category i.

m_i = population in Series 3 category i, in grid square with UTM coordinates x and y.

The per capita emission rate was calculated by summing, in each Series 3 category, the area source contributions from all the Source Inventory activity classifications, then dividing that total by the total population (for all grid squares) for that single Series 3 category. The formula would be:

$$r_j = \frac{1}{P_j} \sum_{i=1}^{88} c_{ij} E_i$$

where the only new variable P_j is the total regional population for Series 3 category j.

The final per capita emission rates for 1975 SO_2 are shown as an example in Appendix D.

While the subjective element in the choice of distribution coefficients is recognized, this method is a valuable tool for compiling a realistic source inventory. If the coefficients are in error, the total quantity of pollutants emitted is not changed; only the geographical distribution will be affected. Further the cross-classification method described here is a substantial improvement over methods previously used to distribute area sources over a large region.

APPENDIX A

BAAPCD 107 Source Category with Percentage Distribution of Point & Area Sources

Source Category No.	Source Category	Percent Distribution	
		Point	Area
	PETROLEUM REFINING		
1	Refining Processes	100	0
2	Other Processes	100	0
3	Upsets, Breakdowns, Flaring	100	0
	CHEMICAL		
4	Nitric Acid	100	0
5	Phthaltic Anhydride	100	0
6	Sulfur	100	0
7	Sulfuric Acid	100	0
8	Titanium Dioxide	100	0
9	Other Chemical	13	87
	OTHER INDUSTRIAL/COMMERCIAL		
10	Pulp and Paper	100	0
11	Metallurgical	3	97
12	Mineral - Asphaltic Concrete Plants	100	0
13	- Concrete Batching	0	100
14	- Glass & Related Products Mfg	100	0
15	- Stone, Sand & Gravel	0	100
16	- Sand Blasting	1	99
17	- Other Mineral	35	65
18	Farming Operations	0	100
19	Food/Agric. Processing	14	86
20	Paint Spray Mist	0	100
21	Wood Products Mfg	0	100
22	Other Industrial/Commercial	2	98
	PETROLEUM REFINERY EVAPORATION		
23	Storage & Blending	100	0
24	Marine Loading	100	0
	GASOLINE DISTRIBUTION		
25	Bulk Plants	100	0
26	Vehicle Filling Stations - Spillage	0	100
27	- Storage Tanks	0	100
28	- Filling Vehicle Tanks	0	100
	OTHER ORGANIC COMPOUNDS EVAPORATION		
29	Storage Tanks - Solvent	0	100
30	- Other Organic Compounds	2	98
31	Industrial Coating - Solvent Base	14	86
32	- Water Base	18	82
33	Coml & Dom Coating - Solvent Base	0	100
34	- Water Base	0	100
35	Degreasers	2	98
36	Dry Cleaners - PERC	0	100
37	- Other Solvents	59	41
38	Rubber Fabrication	2	98
39	Plastic Fabrication	6	94
40	Printing	1	99
41	Other Organics Evaporation	4	96
	COMBUSTION OF FUELS		
42	Domestic	0	100
43	Commercial & Institutional - Gas	1	99
44	- Oil	0	0

APPENDIX A

BAAPCD 107 Source Category with Percentage Distribution of Point & Area Source

Source Category No.	Source Category	Percent Distribution Point	Percent Distribution Area
45	Oil Refineries Ext Combust - NG	100	0
46	- Refinery Make Gas	100	0
47	- Fuel Oil	100	0
48	- Coke	100	0
49	Power Plants - Gas fired Boilers	100	0
50	- Oil fired Boilers	100	0
51	- Coal fired Boilers	0	100
52	- Gas fired Turbines	0	0
53	- Oil fired Turbines	0	0
54	Asphaltic Concrete Plants - Gas	100	0
55	- Oil	100	0
56	Kilns - Gas	85	15
57	- Oil	100	0
58	Turbines - Gas	100	0
59	- Oil	100	0
60	Reciprocating Engines - Gas	0	100
61	- Oil	0	100
62	Other Industrial Combustion - Gas	44	56
63	- Oil	18	82
64	- LPG	100	0
65	- Coke or Coal	100	0
66	- Other Fuels	0	100
	BURNING OF MATERIALS		
67	Residential Incineration	0	100
68	Commercial/Institutional Incin.	0	100
69	Industrial Incineration	0	100
70	Agricultural Debris Burning	0	100
71	Range/Forest Improvement Burning	0	100
72	Accidental Wild Fires	0	100
73	Accidental Structural Fires	0	100
	OFF-HIGHWAY MOBILE SOURCES		
74	Agricultural Tractors - Gasoline	0	100
75	- Diesel	0	100
76	Construction Equipment - Gasoline	0	100
77	- Diesel	0	100
78	Steamships - Cargo & Passenger	0	100
79	- Tankers	0	100
80	- Military	0	100
81	Motorships (Fuel Oil) - Cargo	0	100
82	- Tankers	0	100
83	Motorships (Diesel) - Cargo & Tugs	0	100
84	- Tankers	0	100
85	Fishing & Ferry Boats	0	100
86	Locomotive	0	100
87	Lawnmowers	0	100
88	Misc. Utility Engines	0	100
	AIRCRAFT		
89	Air Carriers	Airport Emissions	
90	General Aviation - Jet		
91	- Piston		
92	Military - Jet		
93	- Piston	Airport Emissions	

APPENDIX A

BAAPCD 107 Source Category with Percentage Distribution of Point & Area Sources

Source Category No.	Source Category	Percent Distribution Point	Percent Distribution Area
	MOTOR VEHICLES		
94	Cars & Light Duty Trucks - Exhaust	Mobile Source Emission	
95	- Evaporation		
96	- Crankcase		
97	- Tire Wear		
98	Heavy Gasoline Trucks - Exhaust		
99	- Evaporation		
100	- Crankcase		
101	- Tire Wear		
102	Heavy Duty Diesel Trucks - Exhaust		
103	- Tire Wear		
104	Buses - Exhaust		
105	- Tire Wear		
106	Motorcycles - 2 Stroke		
107	- 4 Stroke	Mobile Source Emission	

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APPENDIX B

A LIST OF 19 PARAMETERS FROM SERIES 3 PROJECTIONS UTILIZED FOR AREA SOURCE DISTRIBUTION.

Series 3 Projection Variable Code	Series 3 Projection Variable Name	SIC	Description
P1	DWELL		Dwelling unit
P7	AGRE	01	Agriculture production - crops
		07	Agriculture services
		08	Forestry
		09	Fishing, hunting, and trapping
P8	MIN		
		10	Metal mining
		13	Oil and gas extraction
		14	Mining and quarrying of non-metallic minerals, except fuel
P9	MFG 1		
		27	Printing, publishing and allied industries
P10	MFG 2		
		26	Paper and allied products
		28	Chemicals and allied products
		29	Petroleum refining and related industries
		32	Stone, clay, glass and concrete products
		33	Primary metal industries
P11	MFG 3	20	Food and kindred products
P12	MFG 4		
		19	
		36	Electrical and electronic machinery and equipment
		38	Measuring, analyzing and controlling instruments; photographic, medical and optical goods
P13	MFG 5		
		34	Fabricated metal products, except machinery and transportation equipment
		35	Machinery except electrical
		37	Transportation equipment
P14	MFG 6		
		22	Textile mill products
		23	Apparel and other finished products made from fabrics

		24	Lumber and wood products except furniture
		25	Furniture
		31	Leather and miscellaneous plastic products
		39	Miscellaneous manufacturing industries
P15	TRAN		
		40	Railroad transportation
		42	Motor freight transportation and warehousing
		44	Water transportation
		45	Transportation by air
		46	Pipelines, except natural gas
P16	WHOL	50	Wholesale trade
		52	Building materials, hardware, garden supply, and mobile home dealers
P17	FIN		
		62	Security and commodity brokers, dealers, and exchanges
		63	Insurance
		67	Holding and other investment firms
P18	SERV 1		
		73	Business service
P19	SERV 2	82	Educational services
		84	Museum, art galleries, botanical and zoological gardens
		89	Miscellaneous services
P20	GOV		
		91	Executive, legislative and general government
		92	Justice, public order, and safety
P21	RET		
		53 - 59	General merchandise stores Food stores
P22	BUSINESS SERV.		
		80	Health services
		81	Legal services
		96	Administration of economic programs
P23	RET. SERV.		
		70	Hotels, Rooming Rooms, Camps and other lodging places

		72	Personal services
		75	Automotive repairs
		76	Miscellaneous repairs
		78	Motion pictures
		79	Amusement and recreation services
		86	Membership organizations
		88	Private households
P24	OTHER LOCAL SERV.		
		15	Building construction - general contractors
		16	Construction other than bldg. construction - general contractors
		17	Construction - special trade contractors
		41	Local and suburban transit
		47	Transportation services
		48	Communication
		49	Electric, Gas, Sanitary services
		60	Banking
		61	Non bank credit agencies
		66	Combination of real estate, insurance, loan, law offices
		93	Public finance and taxation
		94	Administration of Human Resources programs
		95	Administration of Environmental Quality and Housing programs
		99	Others

APPENDIX C

COEFFICIENT VALUES(c_{ij}) FOR AREA SOURCE DISTRIBUTION

AREA SOURCE DISTRIBUTION PERCENTAGES FOR SERIES 3 ACTIVITY CATEGORIES

Class No.	Source Classification	Series 3 Categories: 1 Dwell.	7 AGRE	8 MIN	9 MFG1	10 MFG2	11 MFG3	12 MFG4	13 MFG5	14 MFG6	15 TRAN	16 WHOL	17 FIN	18 SERV1	19 SERV2	20 GOV	21 RET	22 BUS.SERV	23 RET.SERV	OTHER LOCAL SERV (24)
	CHEMICAL																			
5	Misc. Chem. Proc.																			
	OTHER IND./COM.																			
1	Metallurgical					90			10											
3	Mineral-Concrete					100														
5	Mineral-Stone,Sand & Gravel	10		40		50														
6	Mineral-Sand Blast.					10			5		10	5	5	5	10	10	10	10	10	10
7	Misc. Mineral Proc.			10		90														
8	Farming Operations		100																	
9	Food/Agric. Proc.						100													
0	Paint Spray Mist	5				10			70										15	
1	Wood Products Mfg.	10								80									10	
2	Misc. Ind./Com. Proc.							30	30	30										
	GASOLINE DISTRIB. Vehicle Fill Sta. -																			
6	-Spillage										5						90			5
7	-Storage Tanks										5						90			5
8	-Veh. Tanks										5						90			5
	OTHER ORG. COMP. EVAP. Storage Tanks -																			
9	-Solvent					20		20	20	20	10	5							5	
0	-Misc. Org. Comp.		5	10		20	15	10	10	10	10	5								5
1	Ind.Coat.-Solv.Base				10	10		10	50	10									10	
2	Ind.Coat.-Water Base								90	5									5	
	Com.&Dom.Coat. -																			
3	-Solv. Base	64	3	3							3	3	3	3	3	3	3	3	3	3
4	-Water Base	64	3	3							3	3	3	3	3	3	3	3	3	3
5	Degreasers							10	60										20	10
6	Dry Cleaners-PERC																		100	
7	Dry Cln.-Misc.Solv.																		100	
8	Rubber Fabrication					100														
9	Plastic Fabrication					90													10	
0	Printing				100															
1	Misc. Org. Evap.	10	5	5		50		5	5	5									10	5
	COMBUSTION OF FUELS																			
2	Domestic	100																		
3	Com.&Inst. - Gas			5								5	10	5	10	10	25	10	10	10
4	- Oil																			
1	Power Plts.Coal Boil.					100														
6	Kilns - Nat. Gas					100														
7	Kilns - Oil					100														
0	Recipr.Eng. - Gas																			
1	Recipr.Eng. - Oil		10	10		20											10	20	20	10
	Misc. Ind. Comb. -																			
2	-Gas				10	20	20	10	20	[illegible]										
3	-Oil				10	20	20	10	20	[illegible]										
	BURNING OF MATERIALS																			
7	Resident. Incin.	100																		
8	Com./Inst. Incin.											5	5	10	10	20	10	20	10	10
9	Ind. Incin.				10	20	20	10	20	20										
0	Agric.Debris Burn		100																	
1	Range,Forest Imprv.		100																	
2	Accident.Wild Fire		100																	
3	Accident.Struc.Fire	50			3	3	3	3	3	3		3	3	3	3	2	3	3	10	3
	OFF-HWY MOBILE Agric. Tractors -																			
74	-Gasoline		100																	
75	-Diesel		100																	
	Construc.Equip. -																			
76	-Gasoline	50			3	3	3	3	3	3		3	2	3	3	2	3	3	10	3
77	-Diesel	50			3	3	3	3	3	3		3	2	3	3	2	3	3	10	3
8	Steamships,Cargo/Pas.																			
9	Steamships,Tankers																			
0	Steamships,Military																			
1	Cargo Motorships,Fuel																			
82	Motor Tankers,Fuel		TREAT AS POINT SOURCES IN SHIPPING LANES																	
83	Diesel Motorships - -Cargo/tugs																			
84	Diesel Motorships - -Tanker																			
5	Fishing&Ferryboats																			
6	Locomotives										100									
7	Lawn mowers	100																		
8	Misc. Utility Engs.		20	10		20			10	10	10								10	10

APPENDIX D

AN EXAMPLE OF FINAL PER CAPITA EMISSION RATES FOR 1975 SO_2

```
EMFAC75
        YEAR?1975

        POLLUTANT?  SO2

AREA SOURCE EMISSIONS TOTALS (TONS/DAY) SHOULD BE TYPED IN
FOR 19 SERIES 3 CATEGORIES, IN ORDER 1,7,8,9, ... ,24

EMISSIONS FOR CAT. NO. 1    ?2.73
    PER CAPITA EM. FACTOR FOR CAT.  1 IS     1.54 X 10E-6

EMISSIONS FOR CAT. NO. 7    ?1.56
    PER CAPITA EM. FACTOR FOR CAT.  7 IS    44.23 X 10E-6

EMISSIONS FOR CAT. NO. 8    ?.013
    PER CAPITA EM. FACTOR FOR CAT.  8 IS     6.32 X 10E-6

EMISSIONS FOR CAT. NO. 9    ?.577
    PER CAPITA EM. FACTOR FOR CAT.  9 IS    22.92 X 10E-6

EMISSIONS FOR CAT. NO. 10   ?1.043
    PER CAPITA EM. FACTOR FOR CAT. 10 IS    16.35 X 10E-6

EMISSIONS FOR CAT. NO. 11   ?.997
    PER CAPITA EM. FACTOR FOR CAT. 11 IS    22.63 X 10E-6

EMISSIONS FOR CAT. NO. 12   ?.577
    PER CAPITA EM. FACTOR FOR CAT. 12 IS     5.24 X 10E-6

EMISSIONS FOR CAT. NO. 13   ?1.01
    PER CAPITA EM. FACTOR FOR CAT. 13 IS    11.22 X 10E-6

EMISSIONS FOR CAT. NO. 14   ?1.01
    PER CAPITA EM. FACTOR FOR CAT. 14 IS    35.35 X 10E-6

EMISSIONS FOR CAT. NO. 15   ?.79
    PER CAPITA EM. FACTOR FOR CAT. 15 IS     9.95 X 10E-6

EMISSIONS FOR CAT. NO. 16   ?.167
    PER CAPITA EM. FACTOR FOR CAT. 16 IS     1.30 X 10E-6

EMISSIONS FOR CAT. NO. 17   ?.115
    PER CAPITA EM. FACTOR FOR CAT. 17 IS     3.04 X 10E-6

EMISSIONS FOR CAT. NO. 18   ?.177
    PER CAPITA EM. FACTOR FOR CAT. 18 IS     2.11 X 10E-6

EMISSIONS FOR CAT. NO. 19   ?.178
    PER CAPITA EM. FACTOR FOR CAT. 19 IS     1.86 X 10E-6

EMISSIONS FOR CAT. NO. 20   ?
??.145
    PER CAPITA EM. FACTOR FOR CAT. 20 IS     1.17 X 10E-6

EMISSIONS FOR CAT. NO. 21   ?.181
    PER CAPITA EM. FACTOR FOR CAT. 21 IS      .58 X 10E-6

EMISSIONS FOR CAT. NO. 22   ?.198
    PER CAPITA EM. FACTOR FOR CAT. 22 IS      .90 X 10E-6

EMISSIONS FOR CAT. NO. 23   ?.557
    PER CAPITA EM. FACTOR FOR CAT. 23 IS     2.90 X 10E-6

EMISSIONS FOR CAT. NO. 24   ?.191
    PER CAPITA EM. FACTOR FOR CAT. 24 IS      .51 X 10E-6

     TOTAL EMISSIONS= 12.216
```

AQMP/Tech Memo 22 November, 1977

H. Kollo
V. Petrites

REGIONAL TRAVEL PROJECTIONS FOR AQMP

This memo documents the regional travel forecasts generated for the AQMP. The methodology is described in some detail and summary tables of each travel run are presented.

METHODOLOGY

Six travel simulations were conducted for the AQMP. Four of these, which comprise the baseline forecasts (existing trends), were done by applying the FRATAR growth factoring model to vehicle trips. The other two were developed in two phases to simulate the effect of improved transit service and highway operating cost increases on modal choice. The following list summarizes the regional travel forecasts:

1	1975 Base Year	FRATAR
2	1985 Series III Base Case 1	
3	2000 Series III Base Case 1	
4	2000 Series III Base Case 2	
5	1985 Transportation Control Plan	FRATAR/MODAL CHOICE
6	2000 Compact Land Use	

BASELINE CASES - FRATAR METHODOLOGY

The basic premise of the FRATAR method is that the distribution of forecast-year trips from a zone is proportional to the base-year trip-distribution pattern modified by the growth factors of the zones under consideration. The growth in trips is determined by the growth in the most causal socio-economic variables characterizing the zone, i.e., at the residence zone, the growth in work trip productions is proportional to the growth in employed residents. Likewise, at the work zone, the growth in trip end attractions is proportional to the growth in employment. The distribution of trips in the model is not sensitive to changes in the transportation networks, thus reinforcing the continuation of the existing trends in travel patterns. This is consistent with a baseline forecast.

Data Base

The 1965 BATSC Home Interview Survey and the resulting travel data base were revised in the MTC's Travel Model Development Project during 1976. The data base for this project included a refactoring of the Home Interview Survey to the new estimate of dwelling units made by ABAG (1965 BACKCAST data of May 1976). It also included the development of screenline adjustment factors which resulted in a revised travel data base for 1965. This revised set of trip tables was the basis for the AQMP baseline projections.

1965 Base Year Trip Table Preparation

The intra-regional vehicle trip tables were prepared by three trip purposes: homebased work, homebased non-work, and non-homebased. These were at the 290 zone level. They were expanded to 440 zone matrices using production-end and attraction-end splitting factors. The reason for this was to enable trip assignment to the highway networks at 440 zones. The production-end factor was calculated using 440 to 290 zone proportions of dwelling units, and the attraction-end factor was calculated using the employment proportions. These factors were applied to all homebased trips. For non-homebased trips, employment proportions were used for both the production and attraction ends.

The external cordon trips from the 1965 surveys were also expanded from the 290 to 440 zones in a similar manner.

Socio-Economic Data

Four variables were chosen as the best indicators of growth in trip patterns. These were: employed residents, population, dwelling units, and total employment for each of the 440 zones. Growth in these variables to 1975, 1985 and 2000 was considered indicative of the expected growth in travel. The ABAG Series 3 Provisional Base Case 1 projections to 1985 and the "modified Base 1" and Base Case 2 to the year 2000 were used as a basis for the urban growth. Zonal factors were tabulated at the 440 zones, thirty districts and nine counties for evaluation. Combinations of these factors were used in the FRATAR Model to generate the projections.

Trip Generation and Distribution

Future year trip generation and distribution was carried out using 1965 vehicle trip tables by purpose and 440 zone trip production and attraction growth factors in the FRATAR iterative model. The growth factors determined the trip generation for the future year, and the 1965 trip tables determined the distribution of trips. Ratios of future year to 1965 values of the following variables were used as FRATAR factors:

Trip Purpose	Production-end factor	Attraction-end factor
Homebased Work	Growth in employed residents	Total employment growth
Homebased Non-Work	Average of population and dwelling unit growth	"
Non-Homebased	Total employment growth	"

The sum of retail and service employment was investigated as a proper attraction-end growth factor variable for homebased non-work trips. It was not found to be any better an indicator than total employment.

The external cordon trip tables were also estimated for 1975, 1985 and 2000. The assumption made was that these inter-regional trips would grow also in accordance with this region's socio-economic growth. Therefore, the 1965 tables were multiplied by a factor of 1.5 for 1985 and 1.75 for 2000 uniformly. It was felt that this was the most expedient way to deal with this class of trips. Since these trips are long trips, they contribute a large amount of vehicle miles of travel relative to their size. Therefore, their inclusion and factoring were considered necessary.

Trip Assignment

The future year vehicle trip tables were aggregated to two trip purposes for each projection year, for purposes of trip assignment. Work trips were loaded onto the 1985 "peak" network and homebased non-work, non-homebased and external cordon were added together and assigned to the 1985 "off-peak" network. The network used was the 1985 highway network labeled R850. The 1985 and 2000 trips were assigned independently and the output tapes were made available to ABAG for air quality analysis together with trip end-productions, attractions and intrazonal trips by 440 zone.

TRAVEL FORECASTS - FRATAR/MODAL CHOICE METHODOLOGY

Two of the travel projections did involve significant changes to the transportation picture. The 1985 Transportation Control Plan (TCP) run postulated such changes as additional transit service and higher bridge tolls. The 2000 Compact Land Use (CLU) run started with a densification of development along major transit corridors, with a corresponding increase in capacity to service the expected demand.

It was felt that the changes would primarily affect work trips. Thus, for both runs, the work person trips were factored up using the FRATAR technique. The production-end factor was again Growth in Employed Resident, with the attraction-end factor being the Total Employment Growth. These trips were then input to a slightly modified version of the Mode-Split Model that is part of the MTCFCAST travel modelling system. This model split the person trips into three groups: Transit, carpool, and drive-alone. The vehicle trips were then computed from the latter two categories, and assigned to the 1985 network.

The non-work trips were handled by factoring up vehicle trips with the FRATAR technique as before.

1985 Transportation Control Plan (TCP) Forecast

The following assumptions were coded into the 1985 run.

-- All parking charges were increased by 35% for the drive-alone segment. (35% tax)

-- All transit wait times were decreased by 17%. (20% increase in transit service)

-- A toll of $1.25 was assessed on all trans-Bay crossings in the peak-period network.

-- Terminal times in zones 419-423 and 426-430 were increased by 5 minutes. (Auto control zone in San Francisco).

-- The speeds for the shared-ride mode were set at 55 MPH on the following segments:

Rte. 580 from Rte. 24 to Bay Bridge

Rte. 80 from San Pablo Dam Rd. to Bay Bridge

Rte. 101 from South San Francisco to Bay Bridge (carpool lanes)

-- Inter-zonal work trips and VMT were reduced by 2.9%. (This was done to simulate the effect of a carpool matching program).

-- Intra-zonal trips were reduced by 4.5%. (This simulates the effect of an improved bicycle system.)

2000 Compact Land Use (CLU) Forecast

The Joint Technical Staff was asked to investigate the potential air quality benefits of coordinated land use and transportation development in 2000. Since many of the current constraints to effective transit service are caused by low density development, this alternative sought to investigate the relationship between a denser development within existing transportation corridors.

Since obviously there are many possible "constrained land use alternatives", investigating but one would simply set the scale as to the magnitude of potential air quality benefits. MTC staff therefore sought to set the upper limit to air quality improvement by assuming a wide range of transit improvements throughout the region (many of which could not be constructed given today's limited funding). The following listing summarizes the major transit improvements. Subsequent analysis will identify which of the following improvements would be warranted by the increased transit ridership.

The following changes were made to the 1985 transit network to accomodate the land use pattern in the 2000 CLU:

SamTrans:	50% more buses
Golden Gate Transit:	50% more buses Commute lines connect with MUNI Metro Northwest Extension
AC TRANSIT:	50% more buses in East Bay (excluding Transbay service) Number of buses in contract service doubled
BART:	Shuttle added between Oakland Coliseum and Oakland Airport BART extended to Menlo Park, East Livermore, and Antioch Service frequencies increased
BART Express Buses:	Antioch-Concord-Martinez and Livermore-Bayfair lines shortened to connect with BART extensions Buses on remaining lines increased by 50%
Santa Clara Transit:	Number of buses doubled
Solano County:	Vacaville -- 2 additional local lines coded Fairfield -- 3 new lines coded
MUNI:	MUNI Metro (Light Rail) extended along Geary in Northwest Corridor

Summary Statistics

The table on the following page summarizes the base and forecast travel statistics. In the baseline runs, vehicle trips increased by 43% between 1975 and 2000, with VMT increasing by 69%. This is due to an increase in trip lengths for both work and non-work trips.

By contrast, the low growth assumption for 2000 showed only a 27% increase in trips, with a 48% increase in VMT over 1975.

The 1985 Transportation Control Plan run produced a 2.6% reduction in trips over the baseline run and a 2.5% reduction in VMT. This is consistent with the expectations from the analysis of the individual control measures.

The 2000 Compact Land Use alternative showed a rather dramatic 10.9% reduction in VMT over the Base Case 2 run, which had the same population assumption. The reduction in trips was only 2.1% however. This illustrates that a compact development pattern can decrease vehicle trip length, and also produce a shift to transit.

Table 1

Travel Demand Summary

		TOTAL		INTERZONAL		INTRAZONAL	
		Vehicle Trips	VMT	Vehicle Trips	VMT	Vehicle Trips	VMT
1975	Work	2,144,700	20,775,900	1,924,400	20,199,600	220,300	576,300
	Non-Work	6,904,100	43,762,000	5,304,200	40,623,200	1,599,900	3,138,900
	Total	9,048,800	64,537,900	7,228,600	60,822,800	1,820,200	3,715,100
1985 Baseline	Work	2,543,000	24,362,100	2,272,600	23,645,000	270,300	717,000
	Non-Work	8,215,400	56,128,600	6,387,900	52,517,000	1,827,400	3,611,600
	Total	10,758,300	80,490,700	8,660,600	76,162,000	2,097,700	4,328,600
1985 TCP	Work	2,349,600	22,490,000	2,127,400	21,893,300	222,200	596,700
	Non-Work	8,133,200	55,966,100	6,388,000	52,517,000	1,745,200	3,449,100
	Total	10,482,800	78,456,100	8,515,400	74,410,300	1,967,400	4,045,800
2000 Baseline (BC1)	Work	3,038,400	31,279,600	2,286,900	30,309,100	751,500	970,500
	Non-Work	9,859,400	77,719,800	7,726,400	73,350,300	2,133,100	4,369,500
	Total	12,897,900	108,999,400	10,413,300	103,659,400	2,484,600	5,340,000
2000 (BC2)	Work	2,620,000	26,462,100	2,329,300	25,676,700	290,700	785,400
	Non-Work	8,863,500	69,123,200	6,951,800	65,228,500	1,911,700	3,894,700
	Total	11,483,500	95,585,300	9,281,100	90,905,200	2,202,400	4,680,100
2000 GLU	Work	2,461,300	23,461,400	2,192,600	22,695,000	268,700	766,400
	Non-Work	8,778,800	61,711,400	6,792,600	57,548,900	1,996,200	4,162,500
	Total	11,240,100	85,172,800	8,985,200	80,243,900	2,254,900	4,928,800

AQMP/Tech Memo 23 November, 1977

V. Petrites
P. Maxwell

EVALUATION OF TRANSPORTATION CONTROL MEASURES

Transportation control measures are intended to change current choices of travel by introducing a mixture of pricing and service incentives. An automobile driver may be persuaded to either:

1) Eliminate a journey

2) Reduce the length of a journey

3) "Double up" by carpooling

4) Use transit

Transportation control measures are usually low capital projects designed as "stop gap" measures to induce an immediate change in travel behavior. They are not to be confused with major capital projects -- such as a BART extension or a major freeway project which result in long term travel changes.

EVALUATION PROCESS

The initial step was to assemble a comprehensive listing of potential control measures, which could conceivably reduce emissions in the short-term. Table 1 represents a compilation of measures developed from a review of earlier reports conducted here and elsewhere: the original Transportation Control Plan (TCP) promulgated by EPA in 1973[1], the substitute TCP proposed by the Metropolitan Transportation Commission[2], and the Regional Transportation Plan[3].

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[1]Environmental Protection Agency, "California Transportation Control Plan," Federal Register, November 12, 1973.

[2]Metropolitan Transportation Commission, "Proposed Transportation Control Plan for the San Francisco Bay Area Air Quality Control Region," March 1975.

[3]Metropolitan Transportation Commission, "Regional Transportation Plan," issued in 1973 and updated annually.

TABLE 1. CANDIDATE AQMP TRANSPORTATION STRATEGIES

I. MEASURES TO IMPROVE TRAFFIC OPERATIONS

A. Improve Traffic Flow

1. Computerized traffic control
*2. Ramp metering
3. Traffic engineering improvements
4. Off-street freight loading

B. Reduce Peak-period Traffic Volumes

1. Staggered work hours
2. Four day work week
3. Off-peak freight delivery

II. MEASURES TO REDUCE VEHICLE USE

A. Restrict Vehicle Ownership

1. Additional license fee
2. Registration limits

B. Management of Auto Access

1. Better enforcement of parking regulations
2. Limit on number of parking spaces
3. On-street parking prohibited during peak hours
4. Area license
*5. Auto-free zones
6. Gas rationing

C. Increase Cost of Auto Use

1. Road pricing
*2. Increased parking costs
*3. Parking fee for shoppers
4. Eliminate free employee parking
5. Increased gas tax
*6. Increased tolls
7. "Smog charges"

D. Reduce the Need to Travel

1. Communications substitutes
2. Goods movement consolidation

III. MEASURES TO ENCOURAGE ALTERNATIVE MODE OF TRAVEL

A. Increase Transit Ridership

*1. Additional transit service
2. Fare reductions
3. Improved comfort
*4. Bus and carpool lanes

B. Encourage Pedestrian Mode

*C. Encourage Bicycle Mode

D. Encourage Ride Sharing

1. Toll reduction for carpools
*2. Preferential parking and carpools
*3. Carpool matching information
*4. Assist vanpool formation

---

* Recommended for implementation

Having assembled the initial listing, a three step process was used to select the most promising control measures for EMTF consideration. Budgeting and time constraints precluded a detailed assessment and review of all potential control measures. The first step (or screening) involved a review of previous practice, studies, and technical literature to determine whether the measure would be effective in reducing emissions in the Bay Area. Wherever possible quantitative assessments were sought -- but at this level of analysis much of the review was subjective. The Air Quality Maintenance Technical Advisory Committee participated with staff in a workshop to advise on the initial screening.

The primary focus of the second screening was, wherever possible, to develop a quantitative assessment of measure effectiveness. Transportation modeling techniques were used to estimate tons per day reductions in pollutants. Measures which did not have pollutant reduction potential were eliminated. The final screening involved selection and mixing of measures to provide a balance of incentives and disincentives, and revenue-generating measures to finance improvements.

Since the Air Quality Maintenance planning effort is intended to meet air quality standards "as expeditiously as practicable", only measures which have a high probability of implementation before 1985 were recommended. Throughout the screening process, several evaluation criteria were considered. Although ideally some of the more subjective or attitudinal criteria should have been reviewed by a policy level body, time and program constraints precluded a full discussion. The following criteria were reviewed at each screening level:

1) Emissions reduction effectiveness

2) Cost

3) Institutional structure

4) Ease of implementation

5) Public acceptance

6) Legal requirements

WORK TRAVEL EMPHASIS

The Air Quality Maintenance Planning Effort, like its predecessors, has focused particularly upon the journey to work as being the type of travel most susceptible to modal changes. Because of the regularity and repetitiveness of the commute trip and because of the availability of transit alternatives, the journey to work is more susceptible to a diversion to transit or carpooling in the short term. Other types of travel -- such as shopping, doctor appointments, or shuttling children -- tend to be irregular, occur in locations and times when transit service is not competitive, and often require a vehicle for carrying packages and such like. The vast majority of Bay Area residents who have a <u>true choice</u> between transit and the automobile for this type of travel, have and will choose

the auto. Staff did not believe it possible to make substantial reductions in non-work auto travel by implementing short-term transportation control measures.

The journey to work constitutes only 30 percent of automobile travel in the Bay Area, the remaining 70 percent is composed of the travel purposes discussed earlier -- shopping, personal business, etc. Of the remaining 30 percent, less than half is destined to major employment centers where transit is currently a viable alternative for most persons.

The emission control program for new automobiles has had a major positive impact in reducing regional pollutant emissions. Analyses indicate that in 1975, for example, auto pollutants constituted 33 percent of regional hydrocarbon emissions; whereas in 1985, despite major increases in auto travel, the proportion of regional emissions attributable to the auto will decline to 15 percent. Therefore the proportion of regional hydrocarbon emissions attributable to commute travel is approximately 5%. It is clear that even massive reductions in automobile travel would have only a minor impact on pollutant emissions.

I. MEASURES TO IMPROVE TRAFFIC OPERATIONS

A. IMPROVE TRAFFIC FLOW

This general class of controls is designed to improve air quality by smoothing the flow of traffic. Since certain emissions increase due to "stop and go" traffic conditions, smoothing traffic flow would help reduce overall emissions. Traffic flow improvements are particularly suited to alleviating carbon monoxide problems. However, because of increasingly stringent motor vehicle emission standards for new cars, CO is not expected to be a long-term regional problem in the Bay Area, although local "hot-spots" may surface. These can best be dealt with on an individual basis.

1. Computerized Traffic Control

Traffic flow would be improved through a system of computerized traffic signals on selected arterial streets.

This measure was dropped early in the analysis because only very small reductions in oxidant precursors would be achieved through speed improvement, especially considering the small portion of regional traffic that would be affected. Also, the improved flow might induce additional travel, which would offset any gains in air quality. A quantitative assessment was not conducted.

2. Ramp Metering

Ramp metering is an effective operational tool which can, under appropriate conditions, promote optimum use of a transportation corridor. Its use also tends to improve air quality in two ways: 1) by improving the flow of traffic, and 2) by providing bus bypass lanes at ramps with queues of traffic and thus a time saving to those using buses, which tends to encourage a modal shift. However, if congestion on a freeway is eliminated, there is the possibility that, in the absence of any other land use or transportation actions, additional long-distance trips could be generated.

This measure has been combined with bus and carpool lanes because of possible travel-inducing effects if it were implemented alone. In this form, it has been recommended for inclusion in the draft AQMP. More details may be found in the recommended strategies summaries.

3. Traffic Engineering Improvements

Traffic flow can be improved by a number of small projects which would redesign intersections or small street segments. However, if overall capacity were increased, and more trips generated, there could be a negative air quality effect.

This measure was dropped in the first screening because it would affect only a small portion of travel, and any air quality effects would likely be insignificant. A quantitative analysis was not conducted.

4. Off-Street Freight Loading

Zoning regulations would specify off-street freight handling, which would improve traffic flow and hence air quality. The improved flow would have very little effect on oxidant precursors. Thus this measure was dropped in the initial screening without quantification.

B. REDUCE PEAK PERIOD TRAFFIC VOLUMES

Much of the peak oxidant problem can be traced to emissions generated during the morning hours. This is due to the time required for photochemical reactions to take place. Any reduction or spreading of these early morning emissions could possibly reduce the intensity or shift the location of peak oxidant concentrations. However, current knowledge of oxidant formation indicates that a very large shift in time would be required and moreover the measures in this category would be difficult to implement to the degree necessary to have this significant effect.

1. <u>Staggered Work Hours</u>

This program would shift the daily work schedule so that all employees would not arrive and leave at the same time. This could take the form of (a) "staggered hours," where subgroups of a total work force operate on a fixed schedule, or (b) "flextime," where employees are given the option of determining their own hours within certain limits. This measure could improve air quality by (a) reducing congestion, (b) spreading early morning emissions, and (c) providing employees with an opportunity to adjust their schedules to accommodate other modes of travel.

This measure was eliminated at the initial screening because it would redistribute auto trips, rather than eliminate them. Although the air quality benefits would be slight, it may be desirable to implement this strategy for other reasons, such as reduction in congestion.

2. <u>Four Day Work Week</u>

The standard work week would be shortened to four days, with the work day lenghtened and/or the weekly hours worked shortened. One-fifth of the commute travel could be eliminated, but the additional leisure time would probably generate other recreational or shopping trips.

Because of the potential for additional trips, it was felt that this measure would have only a small effect on air quality, and it was therefore eliminated during the initial screening.

3. <u>Off-Peak Freight Delivery</u>

Freight deliveries would be prohibited during peak periods. This would both reduce peak period traffic and also improve traffic flow by removing the slower vehicles and the trucks stopped while loading.

Only a small percentage of regional travel would be affected by this measure, and so any air quality improvement would be virtually undetectable. This measure was therefore dropped from further consideration during the initial screening.

II. MEASURES TO REDUCE VEHICLE USE

A. MEASURES TO RESTRICT VEHICLE OWNERSHIP

This strategy is designed to reduce travel by limiting the number of vehicles.

1. Additional License Fee

This measure could take a number of forms. It could be a tax increase on all cars, or one which would put a progressively heavier tax on the more polluting cars. Another alternative would be to tax second or third cars in a household and so reduce mobility.

Although this measure is appealing from an implementation standpoint, at least one study[4] has indicated that an annual fee would not be a significant factor in a decision to own or drive a car, unless the fee were extremely high. This measure was thus dropped in the initial screening.

2. Registration Limits

Instead of taxing vehicles with higher pollution potential, this measure would set limits on the numbers of such vehicles which could be registered. The EPA-promulgated TCP proposed a ceiling on motorcycle registrations, but this measure was dropped in the final version.

The implementation and equity problems of this measure are formidable. Because of this, the program could not be set up at a scale which would have a significant effect on air quality. This measure was eliminated during the initial screening.

B. MANAGEMENT OF AUTO ACCESS

This strategy would discourage auto use by restricting the areas where autos may travel or park.

1. Better Enforcement of Parking Regulations

There are many current parking regulations which, if enforced, could discourage certain auto trips. Notable among these are the restrictions on long-term parking which could persuade some commuters to take transit. Other actions, such as enforcement of truck loading zones, could result in a smoother flow of traffic.

Because staff believed that the current number of violators was relatively low, the resultant effect in air quality would be small. However this measure could be effective in jurisdictions where enforcement is currently lax. The measure was eliminated during the initial screening.

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[4]R. H. Pratt Associates, Inc., "Transportation Controls for Air Quality Improvements in the National Capitol Region," October 1976.

2. Limit Number of Parking Spaces

The intent of this measure is to reduce the available parking and so limit the number of autos which can effectively use the controlled area. There are two implementation options: (a) limit the construction of new parking facilities, and (b) cut back the number of parking spaces already available.

The effect of freezing parking in the CBD's was investigated. It was estimated that the 1985 daily emissions inventory would be reduced by 0.4 tons of HC, 5.5 tons of CO, and 0.3 tons of NO_x. Although this measure is effective, it was not included because of the potential inequity between the large downtown areas and the smaller cities. However, it does remain a possible option.

3. Prohibit On-Street Parking During Peak Hours

This measure is designed to improve air quality primarily by improving the flow of traffic. It also serves to discourage certain trips since it limits the available parking.

This measure was not pursued since it is currently practiced by the major cities in their CBD's.

4. Area License

A special license would be required to bring a car into certain designated areas. This would encourage a shift to other modes.

In the past few years there has been increased interest throughout the world in the possibility of imposing user charges to discourage automobile travel in major urban areas. Singapore instituted a program which has been successful but no cities in Europe or North America have tried this concept. A similar type of program was under discussion in Berkeley but was not pursued. Although congestion pricing would certainly be effective in reducing auto-related emissions, this measure was eliminated during the initial screening because of equity problems, implementation problems and public acceptability. It was felt that a similar effect could be obtained, at least in the CBD's, by increasing long-term parking rates.

5. Auto Free Zones

This measure involves the designation of areas within a city (e.g., CBD's) where vehicles are prohibited, with the exception of buses, taxis and emergency vehicles. This technique can result in an improved pedestrian environment and would encourage people to use transit for the entire trip. To develop vehicle-free zones, provisions need to be made for re-routing of through traffic, necessary freight movements, improved transit access, and, in some cases, parking structures on the fringes. This concept has proved successful in a number of cities, mostly in Europe. In the U.S., the major examples of such zones have been shopping malls.

An area within the San Francisco CBD was analyzed as a potential auto control zone. This roughly corresponds to the area recommended in the revisions to the Transportation Element of the San Francisco General Plan.[5] A daily reduction of 0.1 tons of HC, 2.3 tons of CO, and 0.1 tons of NO_x is possible by 1985. This measure is recommended for implementation in San Francisco. The experience gained in this project will determine its potential for other areas in the region. A more detailed description of this measure may be found in the recommended strategy summaries.

6. Gas Rationing

This is usually the "ultimate" measure, when the supply of gasoline is limited in an effort to cut travel and hence emissions. This measure would have significant administrative problems.

This measure was not considered for inclusion in the draft AQMP because of the significant administrative problems and public acceptance problems which would surface. Overall fuel rationing has been suggested as an alternative to gas rationing in an effort to spread the burden over all segments of the economy. It should be noted that since autos will constitute only 15% of regional hydrocarbon emissions in 1985, a 20 percent cutback in gasoline availability would reduce regional hydrocarbon emissions by approximately 23 tons.

C. MEASURES TO INCREASE COST OF AUTO USE

Another way of discouraging auto use is to increase the cost of auto commuting relative to transit or carpooling. However, it generally takes a fairly large increase to effect a significant shift to transit. The more effective pricing strategies are those which serve as daily visible reminders of the real costs of auto commuting.

1. Road Pricing Techniques[6]

This measure could be implemented in two distinct ways. In one, a fee would be charged for the use of certain roads. This is similar to a toll, except that it is more widespread and would likely not be collected at a tollbooth. Instead, some system of in-car meters or electronic scanning devices might be used as automatic billing devices. The second form is a congestion toll, where the rates would increase with the level of congestion.

These measures have not yet been tried as air quality strategies. The technology is not readily available for the first, and the second is still fairly new and untested. For this reason, and because of problems in public acceptability, this measure was dropped in the initial screening. The discussion included under measure B(4) is also applicable to this measure.

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[5] Adopted by the San Francisco City Planning Commission, Resolution No. 7657, January 20, 1977.

[6] Bhatt, Kiran V., "What Can We Do About Traffic Congestion? A Pricing Approach," The Urban Institute, February 1975.

2. Increased Parking Costs

The purpose of this measure would be to discourage auto use by increasing the overall commute cost via additional parking charges. A special parking tax of 35 percent, to be levied on all vehicles parking between 6 and 10 a.m., has been proposed.

It is estimated that this tax would reduce HC by 0.3 tons/day, CO by 3.9 and NO_x by 0.2 in 1985. The 6 to 10 a.m. period was selected to minimize the additional burden on those driving for non-work purposes. This measure has been recommended for implementation. Additional information is contained in the recommended strategy summaries.

3. Minimum Parking Fee at Large Shopping Centers

Most of the measures that were considered focused on the work trip. Other trips, such as shopping, are important in the formation of air pollution but are not as susceptible to diversion to transit. However, many of these trips are made to purchase only one or two items. If the shopper were to consolidate these single trips into one or two weekly trips, the air quality effect could be important. To encourage this consolidation of trips, a minimum 50¢ parking fee at shopping centers that maintain over 500 parking spaces was proposed.

Staff was unable to quantify the effectiveness of this measure because of the lack of experience with this type of action. However, we estimate that shopping trips in 1985 will generate 53 tons of HC, 826 tons of CO, and 39 tons of NO_x daily. This is significant, and therefore this measure was recommended.

4. Eliminate Free Employee Parking

Employers located outside the CBD's virtually always provide their employees with free parking. To encourage these employees to shift to transit or carpools, this measure specifies a $1.00 parking fee be levied at all employee lots of 500 or more spaces.

This measure would reduce HC emissions by 0.9 tons, CO by 13.3 tons, and NO_x by 0.8 tons daily in 1985. Although these reductions are relatively high, it was felt that the current lack of transit access to many industrial areas would be a hardship. Therefore, this measure is not recommended at this time.

5. Additional Gasoline Tax

The gas tax would be raised to reduce the demand for vehicular travel. The extra revenue would be used to finance transit improvements or other non-auto alternatives. Unfortunately, the energy crisis of 1974 demonstrated that, even with a rather large increase in cost, the use of autos did not decrease significantly. This experience showed that a 10% increase in pump price facing the consumer would cut the demand by only

1.5%[7]. In the long run, the application of this measure would probably produce a shift toward smaller, more fuel-efficient cars. The imposition of this measure raises questions of equity, since the poor and those not having access to transit would be penalized most severely.

A 15¢/gallon increase in the gas tax would reduce HC emissions in 1985 by less than 0.1 ton/day. The CO reduction was 0.8 tons/day with NO_x reduced less than 0.1 ton/day. This measure was eliminated during the secondary screening.

6. Increased Tolls

Bridge tolls would be increased to reduce the volume of autos using the facility and to generate revenue which could be used to finance improvements in the transit system. MTC was recently given authority over the level and use of tolls on the trans-bay bridges. Tolls on the Bay, San Mateo, and Dumbarton bridges were recently raised to 75¢. The Golden Gate Bridge District has just adopted a $1.00 toll.

A peak toll of $1.25, with an off-peak toll of $1.00, would reduce HC by 0.2 tons/day, CO by 3.1, and NO_x by 0.2 (1985 emissions). In addition, over $12 million additional revenue would be generated annually, which could be used for transit improvements.

This measure is recommended for inclusion in the AQMP. More details may be found in the recommended strategies summary.

7. "Smog Charges"

This measure would assess an additional charge on the auto driver for the pollution generated by the automobile, thus encouraging a shift to other forms of transport or to less polluting cars. The implementation could be accomplished through some of the measures already mentioned, such as the gas tax or registration fee, possibly accompanied by some rebate scheme for those autos with superior emissions control equipment.

The effectiveness of this measure was judged to be similar to that estimated for the additional gas tax. An extremely high charge was thought necessary to effect significant reductions in auto use -- the measure was therefore eliminated during the secondary screening.

D. MEASURES TO REDUCE THE NEED TO TRAVEL

This strategy is designed to maximize or eliminate unnecessary travel. Unfortuneately, the effectiveness and feasibility of these types of measures are uncertain.

1. Communications Substitutes

Certain trips could be eliminated by using other means of communication. This could include business trips as well as shopping trips. The technology for visual communications is becoming available. However, the extent to which

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[7] Metropolitan Transportation Commission, "Proposed Transportation Control Plan for the San Francisco Bay Area Air Quality Control Region," March, 1975

the public will adapt to these new systems is uncertain. The rapid growth in electronic communications in the past decade has not reduced the need to travel.

This measure was eliminated in the initial screening because its proven effectiveness in the near term is doubtful.

2. Goods Movement Consolidation

This measure would reduce truck travel by consolidating freight deliveries Basically, the concept is to have one terminal where the freight is delivered and sorted, and then small trucks would complete the delivery. The measure would thus decrease truck VMT and probably also reduce auto emissions by permitting a smoother traffic flow.

The effectiveness of this measure would be minimal because of the small percentage of travel that would be affected. The measure was thus dropped in the initial screening.

III. MEASURES TO ENCOURAGE ALTERNATIVE MODES OF TRAVEL

A. INCREASE TRANSIT RIDERSHIP

This set of measures would provide incentives for transit as an alternative transportation mode. For many commuters transit is a viable option, yet additional incentives need to be provided to induce significant diversion from the automobile. The following measures are designed to promote the transit mode.

1. Additional Transit Service

Increasing transit service would increase its availability, decrease the waiting time and in some cases the running time, and generally make transit more competitive with the auto.

A 20% increase in transit operating vehicle miles would reduce 1985 daily emissions by 0.7 tons of HC, 11.2 tons of CO, and 0.7 tons of NOx. This measure is therefore recommended for implementation. Further details may be found in the recommended strategies summary.

2. Fare Reductions

There are a number of variations of this measure. One is to simply reduce or eliminate transit fares. This would probably not be very effective, since fares throughout the Bay Area are already relatively low. A second option is some form of a monthly pass. This has good potential since it would eliminate the psychological impediment of repeated payments and so would encourage the diversion of casual trips to transit. A related option is the coordination of transfers between systems.

Because of the current low fare level, further reductions could conflict with regional policy and potentially state law. The monthly pass would probably not have significant air quality effects, but may be a desirable mechanism for encouraging transit ridership.

3. Improved Transit Comfort

This measure seeks to reduce the differences between the auto and transit modes by improving the comfort of transit service. This would be done by providing shelters at bus stops, better security, more comfortable buses, or other amenities.

It is believed that improved amenities alone would not significantly influence transit demand. Moreover, most of the existing transit development programs in the Bay Area will involve new, comfortable buses, additional bus shelters and radio communication. Thus, this measure was dropped from consideration in the initial screening.

4. Bus and Carpool Lanes

Exclusive lanes for buses and carpools would be provided to give these vehicles a time advantage over single occupant autos. This measure is particularly effective at congestion bottlenecks. Experience in the Bay Area has shown that although the time saving is not large, because the congested areas are short, buses have benefited since they are able to maintain more reliable schedules. Major examples of existing bus priority lanes in the Bay Area include Route 101 in Marin County, Route 280 in San Francisco, through the Bay Bridge Toll Plaza, and other points on freeways.

Analysis has shown that the following emissions reductions could be achieved in 1985.

	HC	CO	NOx
Bus Lanes Only	0.1	1.6	0.1
Carpool Lanes Only	<0.1	0.8	<0.1

Although these reductions are low, they could reinforce other measures, such as the additional transit service. Accordingly, they are recommended for implementation. More detailed information may be found in the recommended strategies summary.

B. ENCOURAGE THE PEDESTRIAN MODE

For short trips, walking is frequently the best alternative. Providing amenities such as wider pavements, or moving sidewalks between major activity centers can encourage people to walk for short trips.

A survey of previous studies indicated that, with the exception of auto-free zones, the provision of these amenities would not produce a significant shift from the auto. Rather, it is the dense land use pattern itself which generally encourages pedestrian activity. Since the auto-free zone was already included as a separate measure, we felt that the provision of these other amenities was not warranted from a strict air quality perspective.

C. ENCOURAGE THE BICYCLE MODE

One strategy which could be particularly effective is the greater use of bicycles

for the short utility trip and interface with transit on the commute trip. During the summer and fall months the weather is ideal for cycling, and the daylight is long enough to provide sufficient time for such trips. A comprehensive network of bike lanes would encourage bicycle use.

The two major deterrents to the extensive use of bicycles have been safety and theft. The first, as statistics bear out, could be greatly mitigated through education, acknowledging the bicycle as a legitimate mode and requiring similar knowledge and qualifications for its use as now is required for drivers of cars. Safe parking for bikes, particularly lockers at transit transfer points, shopping centers and other places, is possible with minimal capital outlay ($175 per locker vs. about $5,000 per parking stall or structure) and would do much to stimulate bicycle utility trips.

The effectiveness of this measure was estimated from previous work on a Parking Management Plan for the Bay Area[8]. Because this measure would affect all trips it has greater potential than many of the other measures which were aimed at the work trip only. Accordingly, the following reductions from the 1985 daily emissions inventory are estimated: 2.0 tons of HC, 31.9 tons of CO, and 1.2 tons of NOx. We thus recommend implementation of this measure to include both bike lanes and adequate stroage facilities. Additional information on this measure may be found in the recommended strategies summaries.

D. MEASURES TO ENCOURAGE RIDE SHARING

Carpooling has good potential as a strategy for reducing vehicle travel. It requires no new capital investment, since the cars are already available. It can offer many amenities that transit cannot, such as door-to-door service. Finally, the cost savings are easily perceived by the individual riders.

The following measures were considered:

1. Toll Reduction for Carpools

   One means of encouraging carpools is to reduce or eliminate the tolls on bridges or other toll facilities. Currently, the trans-bay bridges charge no tolls for carpools during peak hours. The Golden Gate Bridge also allows free passage of carpools.

   Virtually all bridges now offer free passage to carpools during peak periods. Very little could be done to expand this measure, so it was eliminated during the screening process.

2. Preferential Parking for Carpools

   Special lots would be reserved for carpools which would offer an advantage in location and/or price. CalTrans is currently leasing state lots in San Francisco which will be available to carpools for no more than $10/month. Other fringe parking lots are being planned which will aid in carpool pick-ups.

   It is estimated that this measure would reduce HC by 0.1 tons, CO by 1.5 tons, and NOx less than 0.1 tons/day in 1985. Since this measure will reinforce

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[8] Alan M. Voorhees and Associates, Inc., "San Francisco Bay Area Parking Management Plan Guidelines, Draft Final Report." 1975.

other carpooling measures it is recommended for implementation. More details may be found in the recommended strategies summary.

3. Carpool Matching Information

These programs are oriented to providing assistance to those individuals interested in forming carpools. CalTrans currently administers a carpool matching program which seeks to match riders going to major employment centers. This could be expanded to include secondary employment centers and to solicit employer participation.

A method of implementing this expanded scope through the formation of a non-profit corporation is being considered. The effectiveness was estimated in conjunction with the following measure, vanpooling.

4. Assist Vanpool Formation

Vanpooling has potential for replacing cars on the longer commute trips. The passengers pay the capital and operating costs of the van, and the driver is responsible for the operating and administrative aspects. A public entity can assist by matching interested participants, and by facilitating the lease and insurance of the equipment.

The same non-profit corporation is intended to encourage vanpooling by providing the stated services. The emissions reduction potential of this and the carpool matching program is 1.7 tons of HC, 20.4 tons of CO, and 1.2 tons of NOx daily in 1985. Both measures are recommended for inclusion in the AQMP. More information may be found in the recommended strategy summary.

AQMP/Tech Memo 24 November 1977
T. Perardi

ANALYSIS OF SUSPENDED PARTICULATE MATTER IN THE SAN FRANCISCO BAY REGION

Various ambient air quality standards for particulate have been exceeded in portions of the Bay Region during recent years. Some aspects of this problem are documented in AQMP Tech Memo 3.[1] Livermore, for example, showed exceedences of the State 24-hour standard (100 $\mu g/m^3$) on 41% of the sampling days in 1976, and also exceeded the State annual geometric mean (60 $\mu g/m^3$) in 1974, 1975 and 1976. The Federal annual geometric mean (75 $\mu g/m^3$) was also exceeded in 1975 and 1976. The Federal primary 24-hour standard (260 $\mu g/m^3$), by contrast, is exceeded only rarely in the Bay Area.

This ambient air quality experience suggests the need for more particulate control measures in an effort to attain Federal and State ambient air quality standards. A knowledge of the sources of particulate matter is desirable, so that an effective control program can be developed. This apparently simple determination is in fact quite complicated. There are so many sources of particulate matter that is difficult to develop even a general classification scheme.

Some particulate matter comes from natural sources, including ocean salts, soil particles, pollen, plant and insect parts. A greater amount, however, is a result of man's activities, such as: 1) combustion products in domestic, commercial, manufacturing, transportation and agricultural activities; 2) rubber tire and roadway dust from vehicle movements; 3) natural dusts raised by mining, quarries, agriculture and construction; 4) man-made particulate such as sawdust, paint spray and manufactures. A further complication is the formation of liquid or solid particulates from gases in the atmosphere. These are called "secondary" as distinct from "primary" particulate which enters the atmosphere already in liquid or solid form.

In an effort to identify the major sources of the particulate matter in the Bay Area, a project was undertaken to compare chemical analyses of source and ambient particulate. The concept of material or mass balances can be applied to derive quantitative links between sources and receptor sites. Livermore, San Jose and Fremont were chosen for analysis because these sites generally record the highest TSP readings in the Bay Area.

AMBIENT DATA BASE

The Bay Area Air Pollution Control District has collected some data on particulate catch composition over a period of several years. Limited chemical analyses are available on 24-hour hi-vol sampler catches from several stations in

the ambient air monitoring system. The samples were collected on cellulose filters at intervals of six or twelve days. The BAAPCD laboratory analyzed the samples for: Cd, Cu, Pb, Mn, Zn, SiO_2, NH_4, SO_4, Cl, NO_3 and "loss on ignition." This choice was not made for the specific purpose of material balance analysis, and several useful elements are not available. A more productive analytical scheme is proposed in the "Recommendations" section.

SOURCE DATA BASE

Chemical composition data for sources were taken from the literature, primarily from work by S.K. Friedlander[2,3] at California Institute of Technology. The main contributions to primary particulate are thought to be sea salt, soil dust, auto exhaust and tire dust. Very little fuel oil was burned in the District in 1975 and almost no coal, so fly ash from those sources was not considered. No specific major point sources were included in the analysis, because for the three receptors considered (Livermore, San Jose and Fremont monitoring stations) the only important point sources produce only natural kinds of particulate matter. Quarries around Livermore produce soil-like dusts in the air. Two salt companies near Fremont contribute particulate which is the same as sea salt. Asphalt hot mix plants in San Jose, Fremont and Pleasanton also produce soil-like particulate matter in the exhaust from their aggregate drying kilns. These anthropogenic contributions cannot be split out from the natural sources of the same composition.

One major particulate point source near Fremont produces phosphate products, with particulate emissions of 0.2 tons per day.[4] This source cannot be included in the mass balance analysis, however, because neither phosphate nor phosphorous is included in the particulate catch analytical scheme.

Soil compositions were derived for local conditions, based on data from Dr. Isaac Barshad at the University of California at Berkeley.[5] Local condition sea salt calculations were based on chlorine loss measurements reported by Martens _et al_.[6]

ANALYSIS

If detailed analyses are available for the ambient particulate catch, as well as the individual composition of contributing sources, then a series of mass balances can be written for individual chemical elements (or specific compounds, or functional groups). Exact or approximate solutions may then be found for the system of equations, to show how much of each element is contributed by each source.

For this project seven mass balances could be made, for organics, SiO_2, Cl, NO_3, SO_4, Pb, and Zn. Seven general source categories were also identified: soil, sea salt, auto exhaust, tire dust, soot (along with other organics), secondary nitrate and secondary sulfate.

RESULTS

The available analyses provide a minimum data base for particulate source identification. The proposed source origin scheme can account for about

85% of the measured particulate catch (Livermore 1975 data), but the lack of detail limits the usefulness of the results. There is no way to distinguish, for example, between primary and secondary carbonaceous particulate. And, as mentioned earlier, there is no way to distinguish between the possible sources of soil-like particulates.

The analysis results, with comments, are listed below by chemical group.

1. Organic TSP is more than 90% man-made. It forms 35 to 40% of the particulate catch at the three sites. Determination of the primary/secondary nature of the carbonaceous matter must depend on separate analytical programs, such as that at the Lawrence Berkeley Laboratory.[7] The soot fraction comes mainly from vehicle exhaust with a smaller contribution from stationary source combustion. In future years, as stationary combustion is forced to liquid and/or solid fuels, this will become a more important source of particulate.

2. Silica is all primary and of natural origin, but it may be entrained and re-entrained in the air as a result of many different man-made activities. These cannot be separated at present. Vehicle travel over roadways is suspected to be a major contributor. In the case of Livermore, local quarry operations are likely candidates. Silica makes up 15 to 18% of the particulate catch at the three stations mentioned, and it is accompanied by an approximately equal amount of other soil components (chiefly light metals and some organics).

3. Chloride in ambient air is almost exclusively from natural primary sources (sea salt). Sea salt particulate provides about 10% of the total catch for Livermore, and slightly larger fractions for San Jose and Fremont which are nearer to the Bay and the ocean coastline. Some of the sea salt chloride is apparently lost as gaseous HCl or Cl_2. A small fraction of the chloride comes from auto exhaust, probably in the form of lead halides.

4. Nitrates form 5 to 9% of the station particulate catch. Nitrates are secondary particulate, formed in the atmosphere from gaseous oxides of nitrogen which are emitted by mobile and stationary combustion sources. Mobile sources are the major contributors. Perhaps two percent of the nitrate catch is primary, as a component of sea salt.

5. Sulfates make up 2 to 4% of the station particulate samples. About one-third of the sulfate is primary, natural particulate from salt, and two-thirds is of secondary man-made origin from sulfur dioxide emissions. Eighty percent of the SO_2 is emitted by major stationary sources such as refineries, sulfur plants, acid plants and fuel oil combustion (ships, utilities). About 20% comes from mobile sources.[4]

6. Lead comprises only 1 to 2% of the ambient particulate catch, but it is reported here because of the possible health hazard

and the availability of the data. It is produced almost exclusively from vehicle exhaust and so is completely primary and man-made with respect to the three stations studied. Lead is the key component to indicate the amount of vehicle exhaust in the region. Freidlander[2] reports that lead is 40% of auto exhaust particulate (with 40% organic and 7% chloride). Other sources indicate 18 to 54% lead in vehicle exhaust particulate, depending on fuel composition, vehicle type, operating conditions, and exhaust system. This point merits further study because of the importance of the source and the changeover to unleaded fuels. The error bracket here is presently fairly large. The auto exhaust contribution to ambient organics was calculated to be less than 3% in Livermore; this result seems much too low. About 15 to 25% was expected.[2,7]

7. Zinc forms only a small percentage of the ambient air particulate--0.12% in Livermore and San Jose, and 0.15% in Fremont. It is included in the analysis because it is the only available indicator for the amount of tire dust in the carbonaceous or organic particulate fraction. Zinc oxide is used in tire tread compounding to the extent of 1 to 2.5% as an accelerator-activator.[8,9] Friedlander[2] uses 1.5%--probably a good average, but again the error brackets are large. This analysis indicates that tire dust contributes about 20% of the organic particulate at Livermore, but this value seems much too high when compared with other studies. Friedlander[2] found levels in southern California cities which would constitute only 2 or 3% of Bay Area particulate.

This analysis and results are based on annual average data collected during 1975 at the three stations mentioned.

DISCUSSION

Before proposing specific particulate control measures, one would wish to know the overall degree of control which will be required, and the major contributing sources. At present only rollback, based on a limited anthropogenic source inventory, is available. A more comprehensive and detailed analysis is needed. Then a more reliable study of the costs and benefits can be made, alternative proposals can be evaluated, and new control measures can be selected.

Although many types of sources may be judged difficult to control, especially for small particles, it seems clear that natural sources will be virtually impossible to control. Work by Levaggi _et al._[10] indicated 26 to 42% of the high-vol catch at various Bay Area stations was non-anthropogenic, that is, of natural origin. The present study shows 30 to 35% soil-like particles and 10 to 15% sea salt, for a total of 40 to 50% natural origin. The entrainment of the soil-like particles may be man-caused, however, so that this category may be subject to some degree of control. Recommendations 4, 5, and 6 are specifically intended to address this problem. More detailed metal analysis should allow tracing of local sources of soil and rock from source to monitors.

In the case of the carbon/organic fraction, analysis of soot content is needed to provide direction to organic control programs. If most carbonaceous material is primary soot, combustion source controls are indicated. If secondary organics are important, evaporative controls could be more effective. Tracing of vehicle exhaust and tire dust fractions must also be improved, as these results appear to be in error. Recommendations 2 and 3 should improve the accuracy of those determinations.

RECOMMENDATIONS

1. Installation of dichotomous samplers at all District monitoring stations. This recommendation anticipates promulgation of size-dependent air quality standards, and clarification of health effects as a function of particle size. Samples will be taken daily by an automated sequencing mechanism. The amount of the particulate catch will be measured by gravimetric or beta attenuation techniques and recorded for each day at very station. The size separation point will probably be around 1 micron. Full chemical analysis (described below) to be required when any federal or state air quality standard is exceeded at the station (including the particulate standard).

2. Chemical Analysis to include:

   a. Visible light absorption measurement for soot content.

   b. Volatile, non-volatile and total carbon analysis by combustion and CO_2 measurement.

   c. Elemental analysis by X-ray fluorescence will provide data on 27 elements including present 6 elements plus Al, Fe, Ca useful for soil/rock analysis; V as fossil fuel indicator; Br as auto exhaust indicator.

   d. Continue SiO_2, NO_3 and SO_4 measurements; add Na and Mg which are not measured by X-ray fluorescence.

3. Confirm or modify source composition data for current local conditions, especially

   a. Zinc in tire dust

   b. Lead, chloride, bromide, organics in vehicle exhaust

4. Literature or field study to measure particulate emissions from roadways. Some data suggest roadway emissions equal to entire present particulate source inventory. Street cleaning/road paving may turn out to be attractive control measures.

5. Extend BAAPCD Source Inventory to include natural contributions to particulate.

6. Initiate a program of source sampling with chemical analysis as above to characterize local natural and man-made particulate. Use local soil and rock analysis to trace local contributors to air samples.

IMPLEMENTATION

We are facing a transitional period in particulate sampling and control. There is general agreement that present standards and the hi-vol sampler are not adequate tools for TSP control and protection of health. A new size-dependent Federal standard is anticipated within a year or two, but the details are not yet fixed. A cutoff point of 3.5 microns is expected, because this is a commonly cited (upper) limit for respirable particulate size. Manufacturers are developing sampling instruments to be compatible with such a standard. There may be some design flexibility in the cut-off point, through changes in sample rate, nozzle design, or pre-filter pore size.

Virtual impactor dichotomous samplers are presently available for less than $5,000. One manufacturer expects to market an improved model with automatic sequencing of up to 36 samples. This should be available by later 1978, with the price still less than $5,000. A cheaper alternative, a stacked filter type sampler, has been developed and described in the literature,[11] but field testing and validation are still in preliminary stages.

EPA decisions will determine the outcome of this transition period, but the particulate source reconciliation program cannot await the Federal pronouncements. It is hoped that the sampling/analysis scheme proposed here will provide (1) the information required for source identification and control programs, (2) hardware and data which will be compatible with future EPA procedures, and (3) a system which can monitor progress towards the goal of attaining the ambient air quality standards for suspended particulate.

A system of dichotomous samplers should be installed as soon as possible at the problem[12] stations, with the following priorities: Livermore, San Jose, Fremont, Pittsburg, Redwood City, Concord, Napa, Richmond, Gilroy, and Vallejo. Planning, budgeting, and purchasing delays would probably make autumn of 1978 the earliest possible startup target. This would allow studies to begin during the 1978 winter particulate season. The main expense will be the incremental labor required, over and above the present particulate sampling program. The samplers themselves and the elemental analysis by x-ray fluorescence are also substantial cost items. Capital costs for x-ray fluorescence equipment are so high--over $80,000--that the analytical work should be contracted out for the first two or three years. Lawrence Berkeley Laboratory and U. C. Davis have equipment and experience for this work.

If the automatic sequencing sampler is actually available during 1978, that model should be installed at Livermore, San Jose, Fremont and Pittsburg. The capability for sequential 1-hour or 2-hour samples will prove to be valuable, and possibly indispensible, for source identification in these high exceedance areas. After the first year experience with 10 problem stations, the remaining 17 ambient air monitoring stations should be provided with dichotomous samplers for the 1979 winter particulate season. EPA standards and sample techniques may be specified by that time. Also an evaluation of the first year's results should influence future decisions on sampler design and analytical programs.

RESOURCE REQUIREMENTS

Costs and labor requirements for the proposed expanded particulate sampling program are estimated in the table on the following page. Assumptions and estimates are listed below.

1. Basic equipment costs

a.	virtual impactor sampler	$ 5,000
b.	stacked filter sampler	300
c.	photon-excited x-ray fluorescence	80,000
d.	beta attenuation	15,000
e.	visible light absorption	500
f.	carbon analysis	1,000

2. Installation costs are 25% of equipment costs.

3. Maintenance and supplies will be 5% of equipment cost per year.

4. Elemental analysis x-ray fluorescence is available at a contract cost of $10 per sample.

5. Technical labor costs are $15 per person-hour, including overhead.

6. Inflation rate will be 6% per year.

7. Number of samples per year for elemental analysis will be:

   a. 250 in 1978 (fourth quarter only)
   b. 1250 in 1979
   c. 2150 in 1980

8. Operating labor requirements, in person-hours, will be:

a.	sampler operation and sample handling		1/4 hour (per sample)
b.	absorption measurement 1 minute		negligible
c.	carbon measurement		1/2 hour (per sample)
d.	source test	50	hour (per test)
e.	in-house wet chemical analysis	1	hour (per sample)

The total costs for this program would be about $500,000 over a three year period. Incremental labor costs make up about 60% of the total. With a coordinated plan and the benefits of the 1978 experience, some efficiencies may be incorporated to reduce 1979 and 1980 costs. In general, when one considers the total expenditure which will be required for control programs, and the benefits derived from cleaner air, the costs of this source identification phase seems well-justified.

RESOURCE REQUIREMENTS FOR EXPANDED PARTICULATE SAMPLING PROGRAM

	Year 1978 (4th qtr.)	1979	1980
Total Number of Stations	10	27	30
Total Number of Samples	1800	19,500	22,000
Number of Source Tests	25	25	25
Samples for Chemical Analysis	250	1250	2150
CAPITAL EQUIPMENT			
Virtual Impactor Samplers	4	6	-
Stacked Filter Samplers*	20**	33	9
Absorption Analysis Equipment	1	-	-
Carbon Analysis Equipment	1	1	-
LABOR			
Total Labor (person-hours)	2075	8000	9975
COSTS			
Labor Costs, including overhead	$ 31,125	$120,000	$149,625
Contracted Analyses	2,500	12,500	21,500
Other Operating Costs	1,719	4,275	4,444
Capital Equipment Costs	34,375	51,125	3,375
TOTAL COST (1977 prices)	69,719	187,900	178,944
Inflation Factor	1.06	1.12	1.19
TOTAL COST BY YEAR	$ 73,900	$210,450	$212,950

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* One station requires three stack filter samplers (with timers) for unattended daily sampling over weekends and holidays. No automatic sequencing device is available for this model.

**Eighteen samplers for six stations plus two samplers for experimental use and source testing.

FOOTNOTES

1. AQMP/Tech Memo 3, "Air Quality: Past and Present," March 1977, pages 4-5.

2. Friedlander, S.K., "Chemical Element Balances and Identification of Air Pollution Sources," Environmental Science and Technology, Volume 7, No. 3, March 1973, pages 235-240.

3. Friedlander, S.K., Smoke, Dust and Haze, John Wiley & Sons, New York, 1977, pages 295-303.

4. BAAPCD, "Emission Inventory, SUMMARY REPORT, Base Year 1975," San Francisco, 1976, page 21.

5. Barshad, Isaac, "A Pedologic Study of California Prairie Soils," Soil Science, Volume 61, No. 6, June 1946, and personal communications.

6. Martens, C.S., et al., "Chlorine Loss from Puerto Rican and San Francisco Bay Area Marine Aerosols," J. Geophysical Research, Volume 78, No. 36, December 20, 1973.

7. Lawrence Berkeley Laboratory, Atmospheric Aerosol Research Laboratory (Novakov, Rosen and others), where preliminary results indicate that most carbonaceous TSP is primary, soot-like material.

8. Morton, editor, Rubber Technology, Second Edition, Van Nostrand Reinhold Co., New York, 1973, page 20.

9. Chemical Technology: An Encyclopedic Treatment, Volume V, Barnes and Noble, New York, 1972, page 480.

10. Levaggi, D.A., et al., "Total Anthropogenic Suspended Particulate as Derived from Chemical Analysis of Chloride and Silicate on High-Volume Samples," APCA Journal, Volume 26, No. 6, June 1976, pages 554-558.

11. Cahill et al., "Analysis of Respirable Fractions in Atmospheric Particulates via Sequential Filtration," JAPCA, July 1977, page 675.

12. "problem" stations are those with over 10% excess days in 1976 or 5% excess days in 1975 (24-hour State standard = $\mu g/m^3$).

APPENDIX

SUMMARY OF PARTICULATE COMPOSITION DATA AND SOURCE ORIGIN CLASSIFICATION ANALYSIS

TABLE 1

Ambient Hi-Vol Particulate Catch Analyses

1975 Annual Averages. Cellulose Filters.

(Concentrations in $\mu g/m^3$ ambient air)

Station	Livermore	San Jose	Fremont
No. of Samples	28	55	28
Dust Loading	64.2	60.0	55.2
Loss on Ignition*	28.3	32.1	28.5
Cadmium Cd	.002	.001	< .001
Copper Cu	.17	.34	.06
Lead Pb	.61	1.22	.79
Manganese Mn	.033	.019	.019
Zinc Zn	.077	.070	.083
Silica SiO_2	11.15	9.28	8.41
Ammonium NH_4	1.51	2.10	2.17
Sulfate SO_4	1.64	2.30	2.33
Chloride Cl	.96	1.82	1.71
Nitrate NO_3	3.36	5.11	5.11
Unknown**	21.9	13.8	14.3

* ashed at 500°C in air

** total dust loading minus all analyzed quantities

TABLE 2

Ambient Particulate Catch Analysis - Livermore, 1975

	Original Data	Corrected**
Loss on Ignition	28.3 ± .1	--
Organics*	--	22.5 ± .6
Lead Pb	.61 ± .1	
Zinc Zn	.077 ± .01	
Silica SiO_2	11.15 ± .1	
Chlorine Cl	.96 ± .1	3.8 ± 2.1
Sulfate SO_4	1.64 ± .1	
Nitrate NO_3	3.36 ± .1	

* "Organics" is calculated from "Loss on Ignition" by subtracting all NH_4, all NO_3, 40% of sulfate and 25% of Pb.

** Original data corrected for 75% ± 10% chlorine loss (see Martens et al., "Chlorine Loss from Puerto Rican and San Francisco Bay Area Marine Aerosols," Journal of Geophysical Research, Vol. 78, No. 26, Dec. 20, 1973). Also, the "Loss on Ignition" value was corrected to "Organics" by method described above.

TABLE 3

Source Composition Data (weight percentages)

	Sea Salt	Soil	Auto Exhaust	Tire Dust
Organic	--	5.9	40.3	87.3
Lead Pb	--	.02	40	--
Zinc Zn	--	< .01	.14	1.5
Silica SiO_2	--	47.9	--	--
Chlorine Cl	55	--	6.8	--
Sulfate SO_4	7	--	--	--
Nitrate NO_3	1	--	--	--

TABLE 4

Various Source Contributions to Livermore Particulate Catch
Concentrations in $\mu g/m^3$ of ambient air

	Soot & Organic	Soil	Sea Salt	Second. Nitrate	Second. Sulfate	Auto Exhaust	Tire Dust	TOTAL	DATA
Organic	16.33*	1.37				.61	4.19	22.5	22.5 ± .6
SiO_2		11.15						11.15	11.15 ±.1
Cl			3.64			.16		3.8	3.8 ±2.1
NO_3			.07	3.29				3.36	3.36 ±.1
SO_4			.46		1.18			1.64	1.64 ±.1
Pb		.005				.61		.61	.61 ±.1
Zn		.002				.003	.072	.077	.077±.01
Subtotal	16.33	12.53	4.17	3.29	1.18	1.38	4.26	43.14	43.14±3.1
Other	-	10.75	2.45	?	?	.14	.54	13.88	21.1
TOTAL	16.33	23.28	6.62	3.29	1.18	1.52	4.80	57.0	67.0 ± 6
error	±.4	±2.4	±3.9	±.1	±.25	±.32	±1.15	±8.5	
Percent** Contrib.	24.4	34.7	9.9	4.9	1.8	2.3	7.2	85.2	100
error (%)	±.6	±3.6	±5.8	±.1	±.4	±.5	±1.7	±12.7	

* by difference, so that total of organics row will be equal to DATA value.
** percentage which each source column contributes to measured (corrected) DATA TOTAL.

CONCLUSIONS

1. Available analyses provide a minimum suitable data base for particulate source identification. It would be desirable to have, in addition: carbon (soot), carbon in compounds, Na, Al, Fe, Ca, and Br.

2. Proposed source origin scheme can account for about 85% of the measured particulate catch (Livermore 1975 data).

3. The "soot and organics" category is large (24% of total particulate) and sources may be amendable to control strategies, but available data does not allow more detailed breakdown of primary or secondary contributions in the category.

4. Error brackets on particulate analyses are relatively small, except on sea salt contribution (because of limited chlorine loss data). The sea salt category is probably not very harmful, nor is it subject to controls. The greatest source of error is the sample volume measurement, which introduces an uncertainty of ± 10% in the total particulate catch measurement.

5. No error analysis is available for the source composition data. We estimate: sea salt Cl ± 2%, soil silica ± 10%, auto exhaust lead ± 5%, and tire dust Zn ± 10%.

6. The simplicity of the analysis scheme allows direct solutions of the chemical balances. There appears to be no requirement for computer use or sophisticated mathematical analysis.

7. Assuming 40% of organic particulate is (primary) soot, the primary/secondary breakdown is as follows:

	Percentages	
	Primary	Secondary
organics	40*	60
SiO_2	100	--
Cl	100	--
NO_3	2	98
SO_4	28	72
Pb	100	--
Zn	100	--

*Assumption based on preliminary data from LBL Atmospheric Aerosol research projects.

8. The anthropogenic/natural source breakdown is:

	Percentages		
	Man-made		Natural
organics	94		6
SiO_2	?	-- 100** --	?
Cl	4		96
NO_3	98		2
SO_4	72		28
Pb	99		1
Zn	97		3

**Probably all silica is form natural sources (soil, clay, rock), but it may be airborne as a result of man's activities such as agriculture, mining, quarry operations, and construction. For example, local gravel pits, asphalt hot mix plants and ready-mix concrete plants could contribute to the Livermore silica catch. Data presently available do not distinguish between these sources.

AQMP/Tech Memo 25

J. Jones-Brown   January, 1978

Evaluation of the Transportation System Needs in the Compact Land Use Alternative[1]

The purpose of this memorandum is to investigate the long range highway and transit needs implications of the Air Quality Maintenance Plan. The methodology used in estimating travel demand is detailed in AQMP Tech Memo No. 22.

SUMMARY

The analysis reviewed the transportation implications of the Compact Land Use strategy which has been proposed as an element of the Environmental Mangement Plan. The analysis was at an unrefined level for two reasons:

(1) The land use plan itself was devised largely as an illustration of the type of emission reductions which could be achieved by integrated land use and transportation decisions. Many other constrained land use patterns are likely to achieve similar reductions.

(2) Forecasting travel demands through a 25 year projection period is very uncertain. A multitude of parameters, which involve federal, state and local policies, will ultimately effect the nature of travel demand in 2000.

The analysis was therefore limited to an "order of magnitude" calculation of the transportation improvements needed to accomodate projected travel demands.

For the highway system, the analyses indicated severe deficiencies by the year 2000 in Marin, Napa and Sonoma counties. Other deficiencies are apparent in northern Contra Costa, on Route 17 at the Santa Clara line and on the Golden Gate Bridge. In general the Compact Land Use strategy appears to lessen the demand for inter-county travel by autos compared with the baseline analysis. If this plan were to be adopted, particular attention would need to be directed toward localized <u>intra</u>-county congestion points.

Overall, the Compact Land Use plan would appear to represent a savings compared with the baseline system. Additional transit service would be needed -- but this could be offset by reduced highway construction. Of course, detailed analyses would be needed at the local level to design additional transit systems and at the state and federal level to develop additional transit funding.

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[1] The Compact Land Use scenario analyzed in this tech memo refers to the original proposal which allocated much of the future growth in employment to the northern counties. This was also known as the "Gro-North" strategy. This alternative has since been altered to distribute employment growth more evenly throughout the region. The results presented here, therefore, are applicable <u>only</u> to the original proposal and <u>not</u> to the alternative currently being considered.

LIMITATIONS OF TRANSPORTATION MODELS

Although transportation demand models are useful in planning studies, their limitations should always be kept in mind. The purpose of modeling is to simplify the relationship between specific variables (income, car ownership, employment, etc.) and a dependent variable (the demand for travel). This effort generates a general decision-making process (model) which seeks to explain the importance and interaction of variables in generating a desire to travel. The simplification is based upon observed behavior of groups of people and thus may not accurately define individual travel decisions, but the process is useful in explaining the travel choice of large groups of individuals. Forecasts are typically the application of the assumed process (model) to a future period to determine the expected value of the dependent variable. This involves a determination of the expected values of the variables used in the model. Here again sóme inaccuracies may be introduced. The value of modeling and forecasting is in simplifying the decision making process, identifying the important causal variables and giving an indication of the general level of the dependent variable. The numbers produced by forecasts are not to be considered exact and are primarily of use in providing some indication of an uncertain future. This limitation is particularly pertinent.

HIGHWAYS

In order to quantify the impacts of different strategies on the regional highway system, travel demand projected for the year 2000 was compared to the 1975 base year travel. Two separate projections were considered for the year 2000: a baseline low growth forecast (2000-BC-2) and the Compact Land Use development plan (2000-CLU) as proposed by ABAG staff. The basis of the comparison was the number of vehicles passing certain grouped sections of the highway system (called screenlines). While these screenlines consist primarily of major highways, some city streets are included because they may be used as alternate routes. An example of this is San Pablo Avenue as an alternative to Highway 80/17 from Richmond to Oakland. Figure 1 shows the different screenlines which were included in the study. Typically, a screenline is made up of more than one facility, but may be limited to a single facility in certain cases, such as bridges. Also, the screenlines are not as continuous or comprehensive as Figure 1 may suggest. A screenline usually consists of separate counting stations at major facilities along the suggested line. As such, it is not expected to provide an exact figure for vehicles passing (in either direction) but only to give a good estimate of the level of interaction between the areas separated by the screenline.

The daily auto trips resulting from the two different year 2000 strategies were loaded onto the highway network and compared to the 1975 screenline volumes. As a general gauge of the extent of highway improvements required, the increase in traffic crossing the screenlines was computed.

When considering a screenline, one must remain aware that one is possibly considering more than one facility. It may be apparent for example, that the Golden Gate Bridge cannot take 70% more traffic (particularly during the peak period) without increased delays in traffic. The same conclusion may be hasty when considering the screenline between San Francisco and San Mateo because

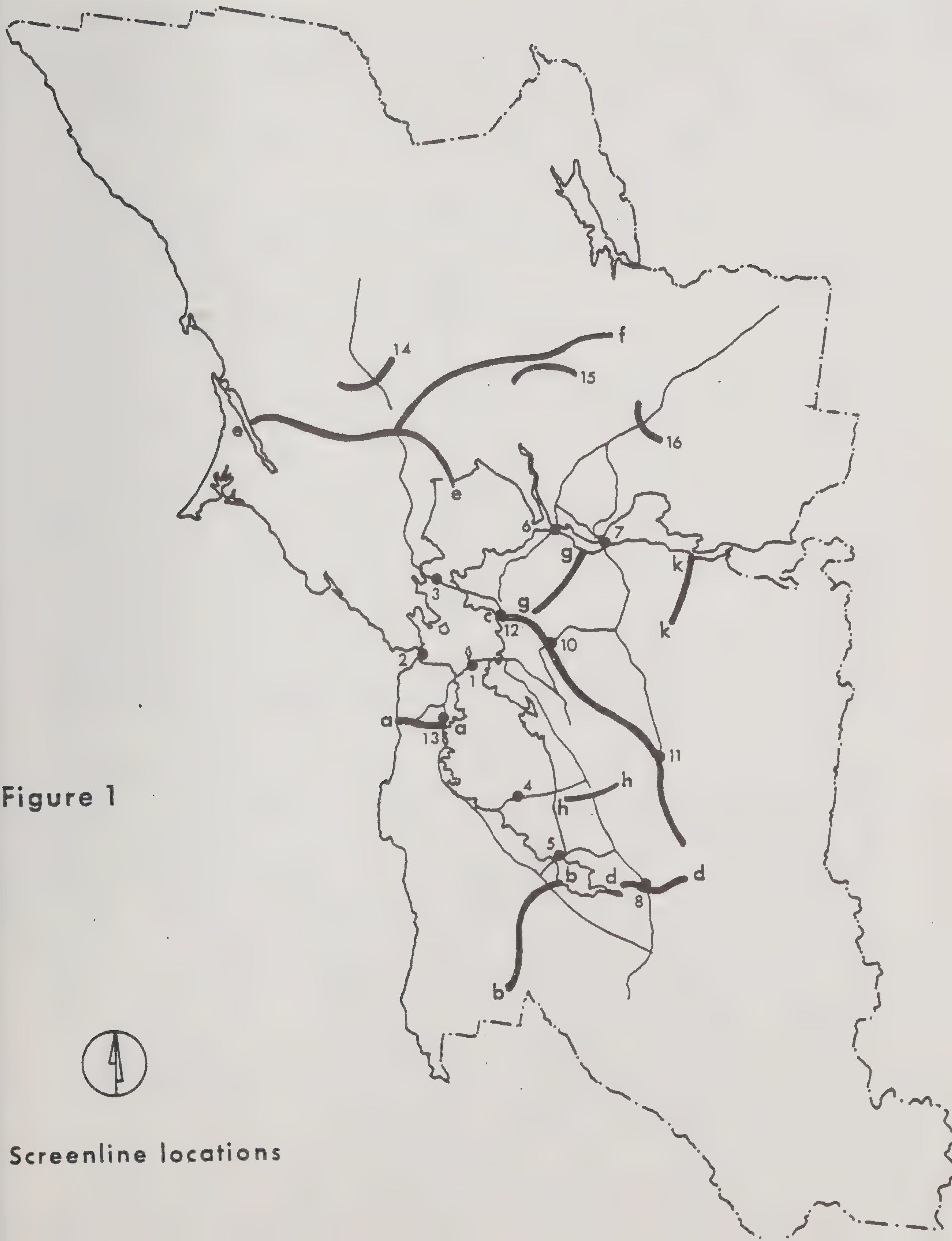


Figure 1

Screenline locations

of the number of facilities involved. The facilities which comprise a screenline may carry traffic at different levels of congestion. Typically, as a facility's congestion gets worse, alternate routes are sought. If alternate routes are available they too may become congested (depending on the total volume of traffic and the capacity of the facilities). If no alternative routes are available (or they are much less attractive than the primary route), the situation quickly becomes one of "grin and bear it."

Thus when considering the impact of traffic on a screenline, one should consider the present level of congestion on the primary route(s), the availability of alternate routes, the capacity of the alternate routes and the volume of traffic to be served. While this analysis will not be conducted at that level of detail, these limitations will be kept in mind. As a general indication of the impact of increased traffic, an increase of less than 20% is considered very mild; an increase of 20-40% is considered moderate; and more than 40% is significant to the point of possibly requiring construction.

Figure 2 provides a visual indication of the impact of increased traffic on a facility. The figure depicts increases of 20%, 40%, 60% and 80% in traffic on the Bay Bridge over a 24 hour period. The peaking characteristics of the original traffic is clearly defined and coincides roughly with the typical work day (the evening peak is not as pronounced as the morning peak because only westbound traffic is shown). When the increase in traffic is not confined to certain periods of the day, the impact of the increase may be lessened by distribution of traffic around the peaks as shown. Figure 3 provides similar information except that the increase in traffic is distributed around the morning peak period. This figure portrays more accurately the impact of increase work trips by auto. The volume under the curve represents the total number of vehicles using a facility over a period of time. The top line represents a capacity constraint for the system (about 2000 vehicles/lane/hour is a good general figure). As the volume is increased 20%, 40%, 60% and 80% the capacity constraint is met and the peak-period begins to lengthen. While this is not suggested as typical of screenlines containing more than one facility, it does present a vivid image of the potential impact of traffic increases.

Table 1 gives the impact on traffic at different screenlines if development were to occur as suggested by the two development strategies. The screenlines are grouped into broad categories depending on the percentage increase in traffic. Figure 4 gives a more vivid impression of the impact of traffic on the screenlines resulting from the Base Case 2 strategy (present trends with low growth). The screenlines and facilities have been coded to indicate the growth in traffic. Screenlines indicate that the increase in traffic exceeds 40% and serious measures, possibly including new construction, may be required. Screenlines indicate an increase in traffic of more than 20% but less than 40%. Such a screenline could be expected to handle the increase in traffic by moderate measures, including operational improvements, possible diversion to alternate routes and minor reconstruction. Unmarked screenlines receive less than a 20% increase in traffic and should be able to handle the additional traffic with only operational improvements. The above are generalizations and not meant to categorize specific facilities. Also, the traffic estimates given are unconstrained; that is the volume is unaffected by present capacity and represents the growth in traffic which would occur if the needed capacity were made available.

It is evident that the traffic increases greater than 20% are fairly evenly

Figure 2: Effect of traffic increases on Bay Bridge (Westbound) over 24 hours

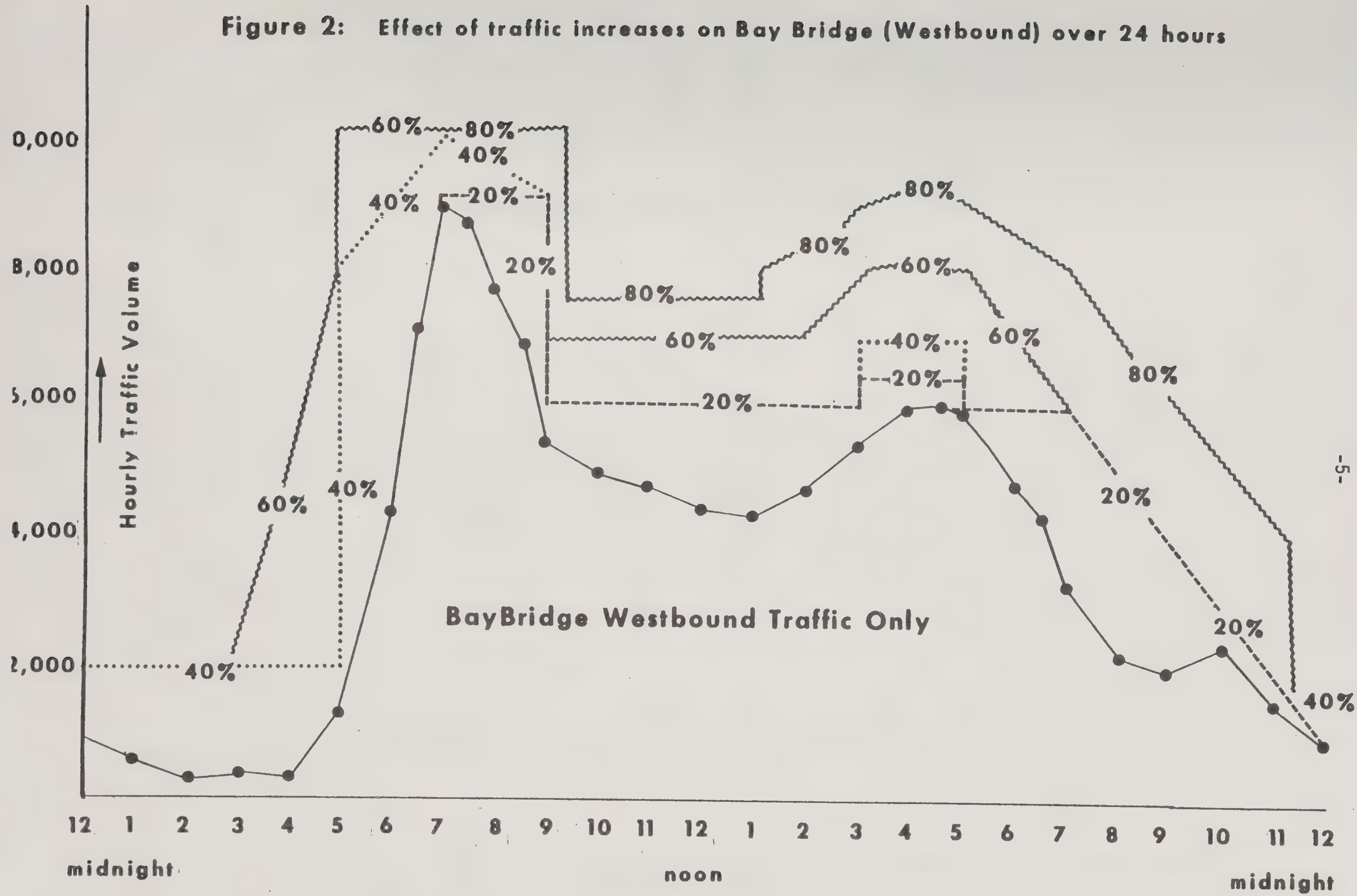


Figure 3: Effect of Traffic Increases on the length of the Peak Period

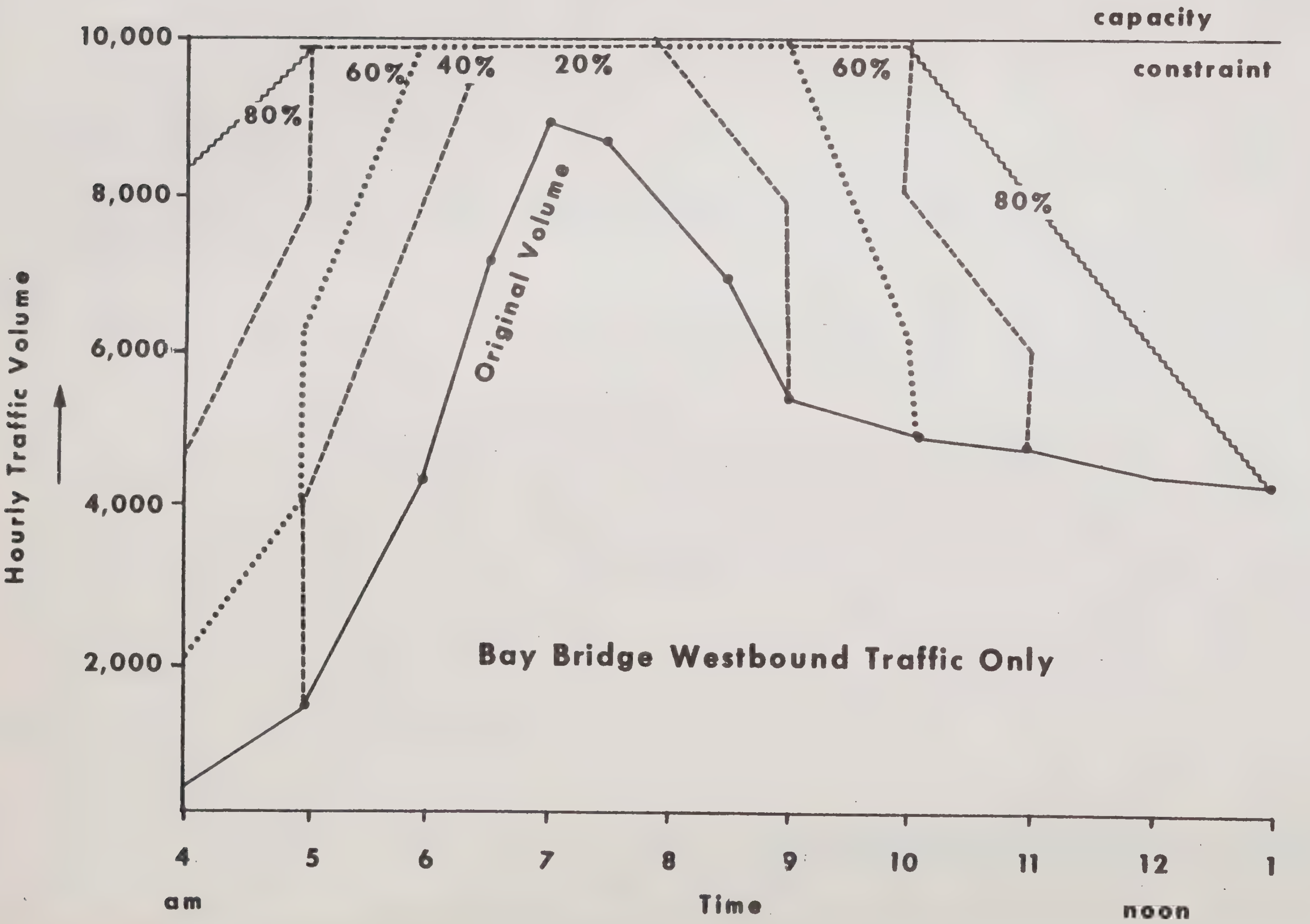


Table 1

24 Hour Traffic Increases at Screenlines

2000 BC-2

Less than 20%	San Francisco-San Mateo (a-a), Bay Bridge (1), San Mateo Bridge (4), Martinez Bridge (7) and North of Napa (15)
20 - 40%	San Mateo-Santa Clara (b-b), Marin-Sonoma (e-e), Sonoma-Napa (f-f), South of Hayward (h-h), Richmond-San Rafael Bridge (3), Carquinez Bridge (6)
40 - 60%	West Contra Costa (g-g), South of Santa Rosa (19)
60 - 80%	East Contra Costa (k-k), Golden Gate Bridge (2)
80%	Alameda-Contra Costa (c-c), Santa Clara-Alameda (d-d), Dumbarton Bridge (5), Caldecott Tunnel (10), and Southwest of Fairfield (16)

2000 CLU

Less than 20%	San Francisco-San Mateo (a-a), South of Hayward (h-h), Bay Bridge (1), San Mateo Bridge (4), Carquinez Bridge (6), Martinez Bridge (7), and North of Napa
20 - 40%	San Mateo-Santa Clara (b-b), West Contra Costa (g-g), East Contra Costa (k-k), Golden Gate Bridge (2), Richmond-San Rafael Bridge (3), Caldecott Tunnel (10), and Southwest of Fairfield
40 - 60%	--
60 - 80%	Santa Clara-Alameda (d-d), Marin-Sonoma (e-e) and Dumbarton Bridge (5)
80%+	Alameda-Contra Costa (c-c), Napa-Sonoma (f-f), and South of Santa Rosa (14)

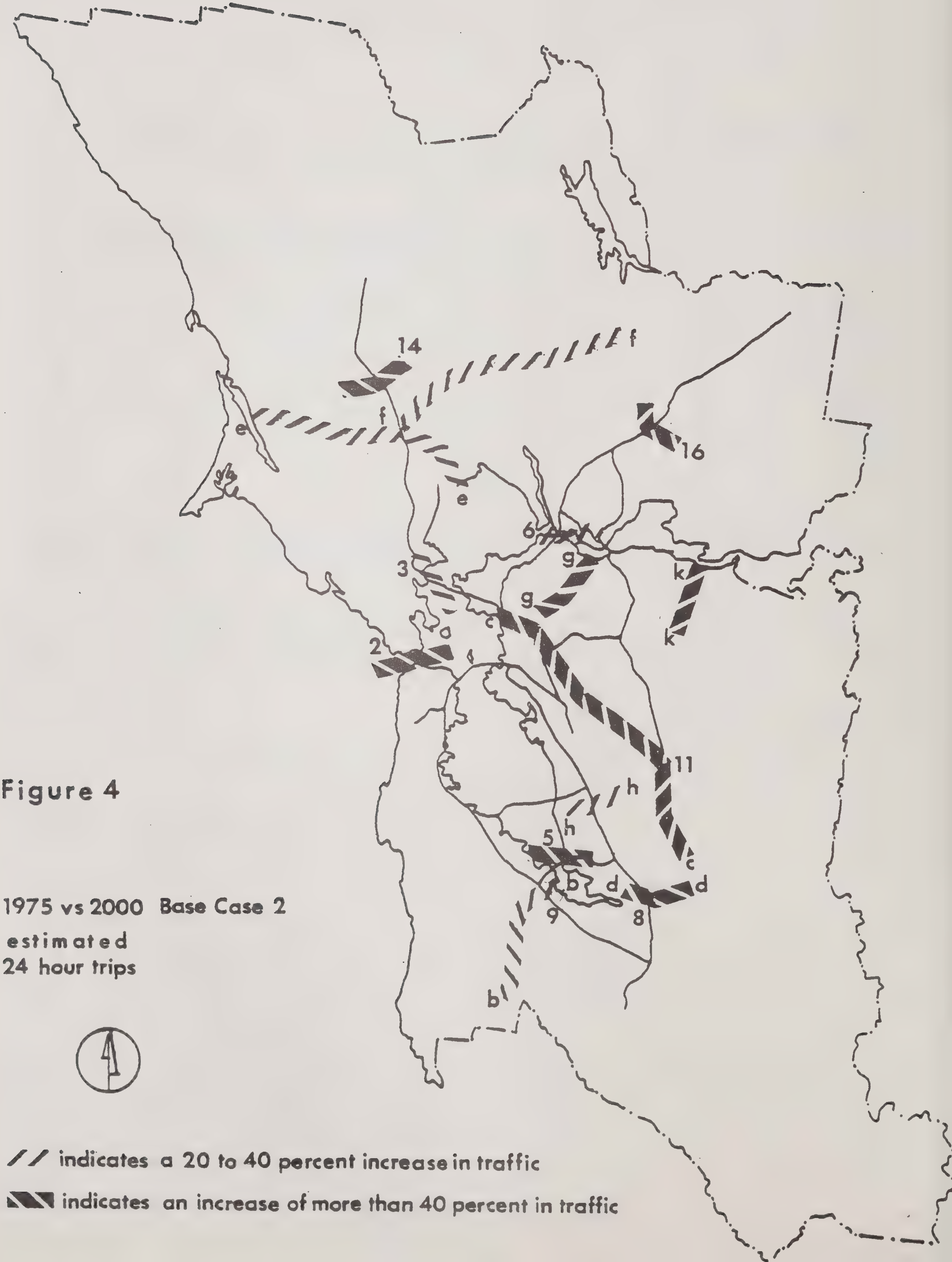


Figure 4

1975 vs 2000 Base Case 2
estimated
24 hour trips

// indicates a 20 to 40 percent increase in traffic

▧ indicates an increase of more than 40 percent in traffic

distributed over the Bay Area, with the exception of the West Bay (San Francisco and San Mateo). It appears that the capacity of the highway system is most severely strained in the East Bay (Alameda, Contra Costa) and the highway system in the north counties deserves careful consideration.

In Figure 5 a similar process is used to illustrate the impact of traffic resulting from the Compact Land Use strategy. A comparison of Figures 4 and 5 shows that many of the same screenlines are coded with some changes in the severity of traffic increases for some screenlines (e.g. screenlines e-e). Without more detailed analysis, it is difficult to draw any conclusions about the relative merits of either strategy in avoiding new highway construction.

In attempting to draw some general conclusions about the need for highway construction, we are interested in the increase of total traffic, but more importantly we are concerned about the increase of traffic during the peak periods. While the distribution of trips over 24 hours is not available, the number of work trips is available. Although the number of work trips includes those at other than peak periods, work trips do provide a surrogate for peak hour trips. There are approximately six peak hour auto trips for all purposes for every ten auto work trips per day.

In Table 2, the increase in work trips at the various screenlines is stratified by percentage for both strategies. Consideration of only work trips produced significant changes in the apparent need for operational and physical improvements. A visual comparison of Figure 2 and Figure 6 provides a clear indication of the difference in needs suggested by all trips and by work trips, assuming a work trip distribution similar to present conditions. Figures 3 and 7 provide a similar comparison (all trips vs. work trips) for the CLU strategy.

More important than the comparisons within each strategy is the comparison between these alternative land use strategies. If we are primarily concerned with the need for new construction on the highway system and believe this is suggested by screenlines or facilities having a 40% or greater increase in work trips, what should be compared is those screenlines which fall into this category as a result of each strategy. The BC-2 alternative results in seven screenlines or facilities which receive a 40% + increase in work trips (versus 3 for the CLU strategy). The predominant concentration of the facilities is in Contra Costa with BC-2 as opposed to the CLU strategy where the most pressing needs are in the northern counties. The CLU strategy results in a less severely impacted highway system than does the base case but an exact estimate of the level of highway investment would require a much more rigorous analysis.

TRANSIT

A similar analysis was conducted for the transit side of the regional transportation system. Because of differences in the type of information available and the operational characteristics of the systems, the identical analytical technique could not be used. For the highway system, trips by automobile, their origin zone and destination zone were estimated and were then assigned to that part of the highway system which would provide for travel between the zones. The number of trips passing over a certain section of highway was

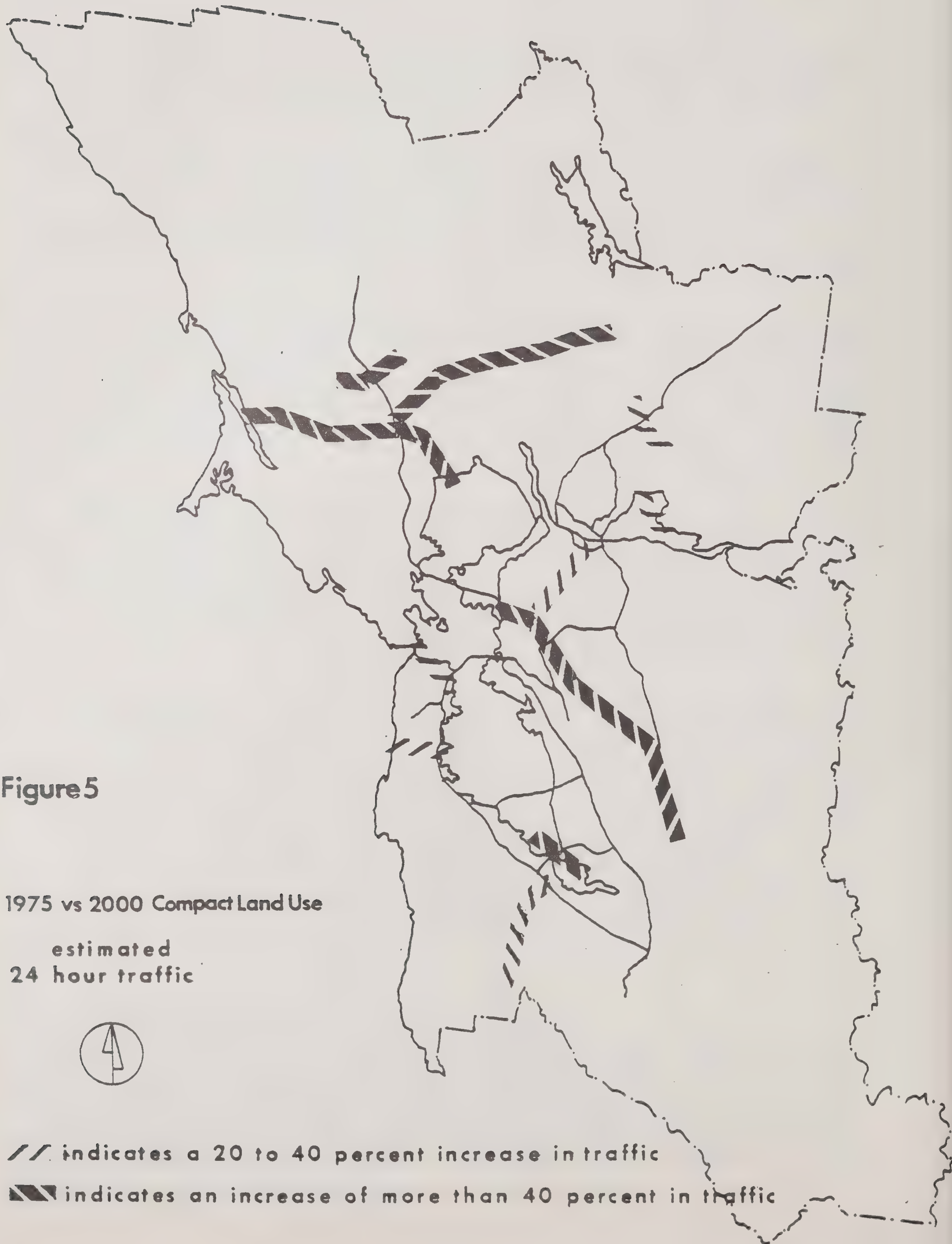


Figure 5

1975 vs 2000 Compact Land Use

estimated
24 hour traffic

// indicates a 20 to 40 percent increase in traffic

indicates an increase of more than 40 percent in traffic

Table 2

24 Hour Work Trip Increases at Screenlines

2000 BC-2

0 - 20%	San Francisco-San Mateo (a-a), Marin-Sonoma (e-e), Richmond-San Rafael (3), Bay Bridge (1), San Mateo Bridge (4), Martinez Bridge (7)
20 - 40%	San Mateo-Santa Clara (b-b), Alameda-Contra Costa (c-c), Napa-Sonoma (f-f), South of Hayward (h-h), and Dumbarton Bridge.
40 - 60%	West Contra Costa (g-g), East Contra Costa (k-k), Golden Gate Bridge, Caldecott Tunnel
60 - 80%	Santa Clara-Alameda (d-d)
80%+	Carquinez (6), South of Santa Rosa (19), North of Napa (15), Southwest of Fairfield (16)

2000 CLU

0 - 20%	San Francisco-San Mateo (a-a), San Mateo-Santa Clara (b-b), Alameda-Contra Costa (c-c), Bay Bridge (1), Richmond-San Rafael Bridge (3), San Mateo Bridge (4), Martinez Bridge (7), Caldecott Tunnel (10) and Southwest of Fairfield (16), South of Hayward (h-h), East Contra Costa (k-k), Dumbarton Bridge (5), and Carquinez Bridge (6)
20 - 40%	Santa Clara-Alameda (d-d), West Contra Costa (g-g), North of Napa (15), Golden Gate Bridge (2)
40 - 60%	Marin-Sonoma (e-e)
60 - 80%	Napa-Sonoma (f-f), South of Santa Rosa (14)
80%+	--

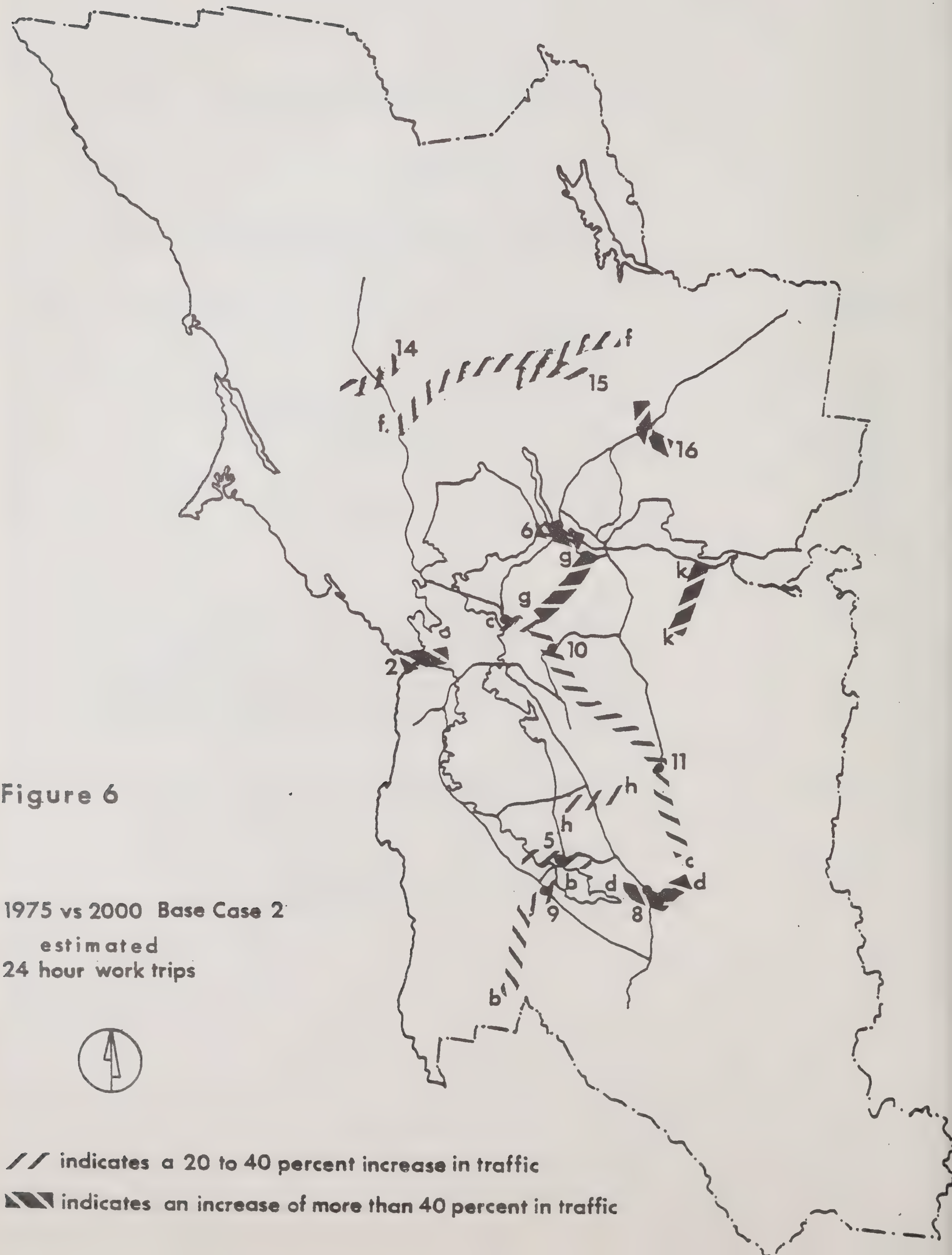


Figure 6

1975 vs 2000 Base Case 2

estimated
24 hour work trips

// indicates a 20 to 40 percent increase in traffic

▮▮▮ indicates an increase of more than 40 percent in traffic

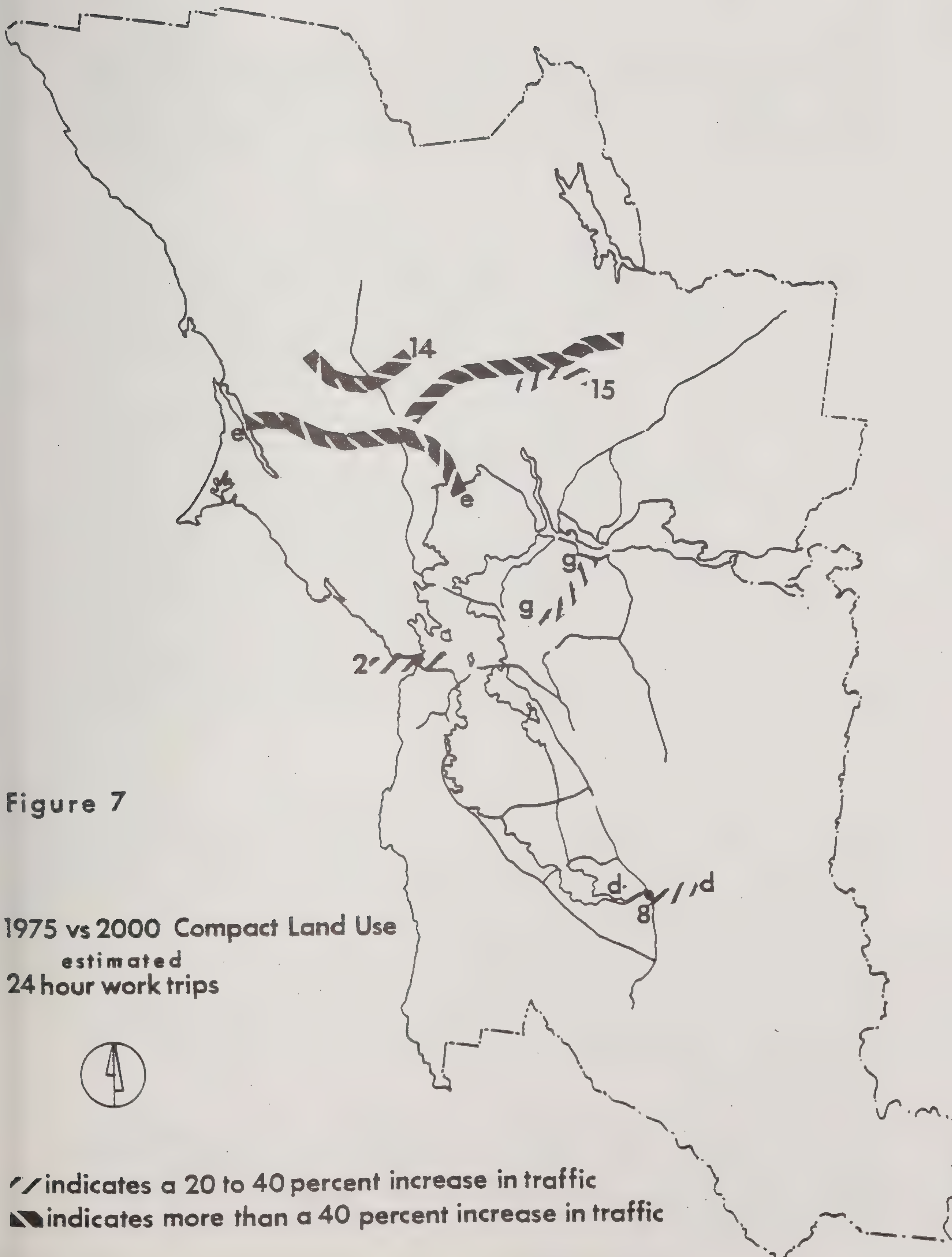


Figure 7

1975 vs 2000 Compact Land Use
estimated
24 hour work trips

indicates a 20 to 40 percent increase in traffic
indicates more than a 40 percent increase in traffic

available directly from this information and provided a gauge of the need for expansion of the system. For the transit system, only work trips produced in each district and distributed to each of the 30 districts of the region was available. No assignment to the transit network had been made. Such an assignment would have been of limited value since projecting future transit routings in detail is virtually impossible.

Network Representation

The data available for estimating the capacity requirements of the transit network was 24 hour work trips for 1975 and 2000 CLU. While these numbers provide a very general indication of the change in demand for transit service, it is not possible to translate it directly into specific needs (i.e. 20 buses vs. 200 buses). In order to obtain a more direct measure of the increased demand for transit services a hypothetical transit network was created. This network consisted of a set of nodes and links connecting those nodes. The nodes are basically point representations of all origins and destinations within each district. The links are linear representations of routes connecting nodes. Figure 8 shows the 30 districts of the San Francisco Bay Region and Figure 9 gives the hypothetical network created to accomodate transit travel between these districts. This network is a gross simplification both by necessity and by design. Each link represents all possible transit routes between districts and as such cannot capture the variations in travel time or costs of those routes. The major benefit of this hypothetical network is that transit trips can be assigned to links and related directly to equipment requirements. While these estimates of equipment requirements are expected to generally underestimate needs, they do provide a realistic order-of-magnitude estimate. One significant limitation of the network is that it does not account for the distribution of trips within a district or trips which take place entirely within a district. Therefore the analysis will consider trips between districts, (inter-district trips), and trips within each district (intra-district trips), separately.

Demand Factoring

In considering inter-district transit trips, the number of work trips (over a 24 hour period) was available for 1975 and 2000 CLU. While such figures do give a general impression of the change in transit demand, they are not directly translatable to equipment requirements, even if loaded onto a transit network. Past experience has shown that peak period travel is the major determining factor for capacity requirements in both transit and highway networks. A comparison of work trips over 24 hours on transit and A.M. peak period transit travel for all purposes was undertaken. These figures were available from a past travel survey of the Bay Area. It was found that for every two work trips by transit in the Bay Region (in a 24-hour period), one A.M. peak period trip by transit occured. This was not taken to be a causal relationship and no statistical relationship was assumed. While this 2:1 ratio would change significantly if work hours were staggered, it was assumed to hold true for 2000 as well as 1975.

First the 24-hour work trips for 1975 and for 2000 CLU were assigned to links on the network. This involved a determination of the probable route of travel between any two districts of the region and assignment of the trips between those two districts to every link used. The traffic on each link (24 hour work trips) was then converted to A.M. peak period trips. The

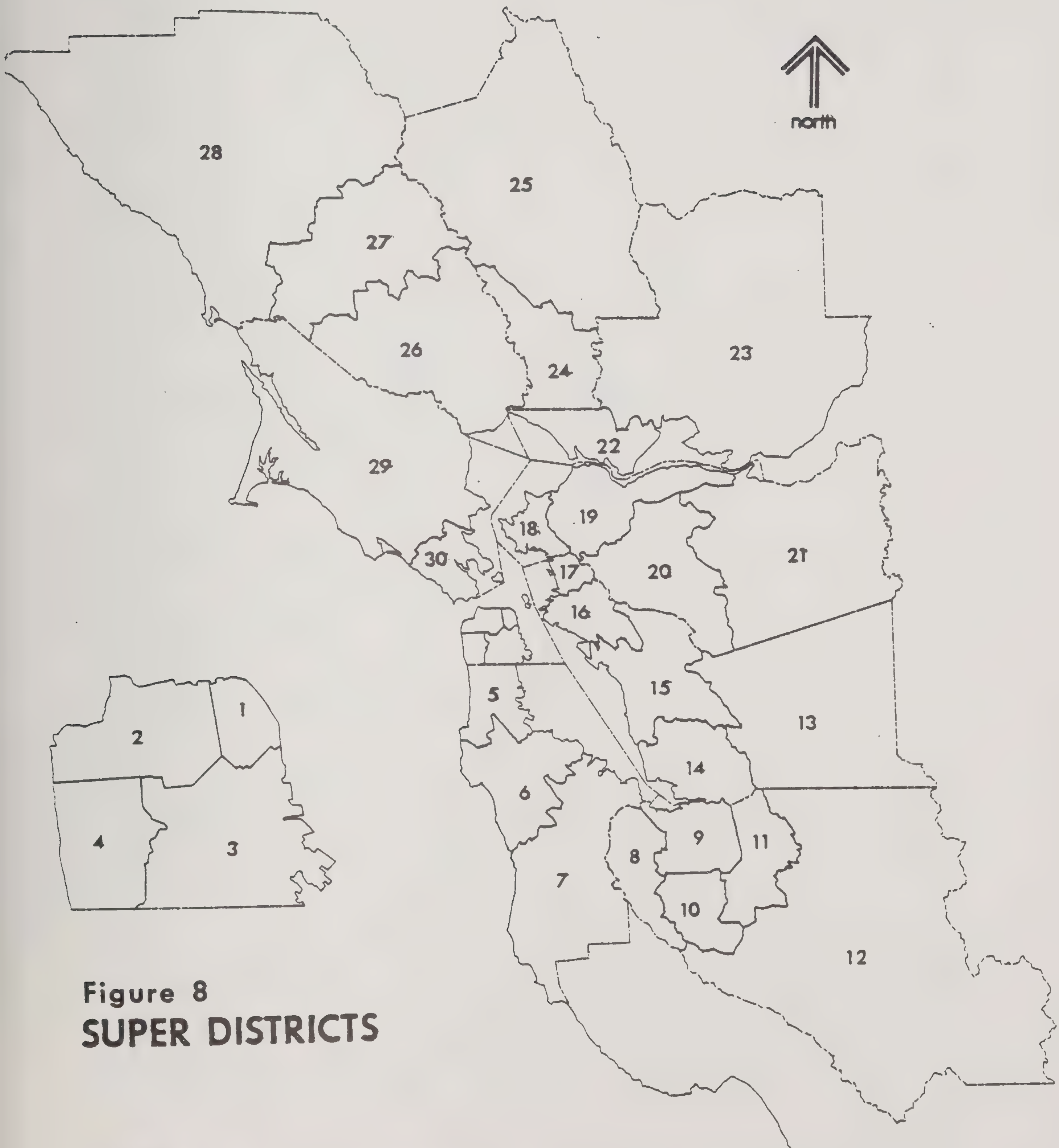


Figure 8
SUPER DISTRICTS

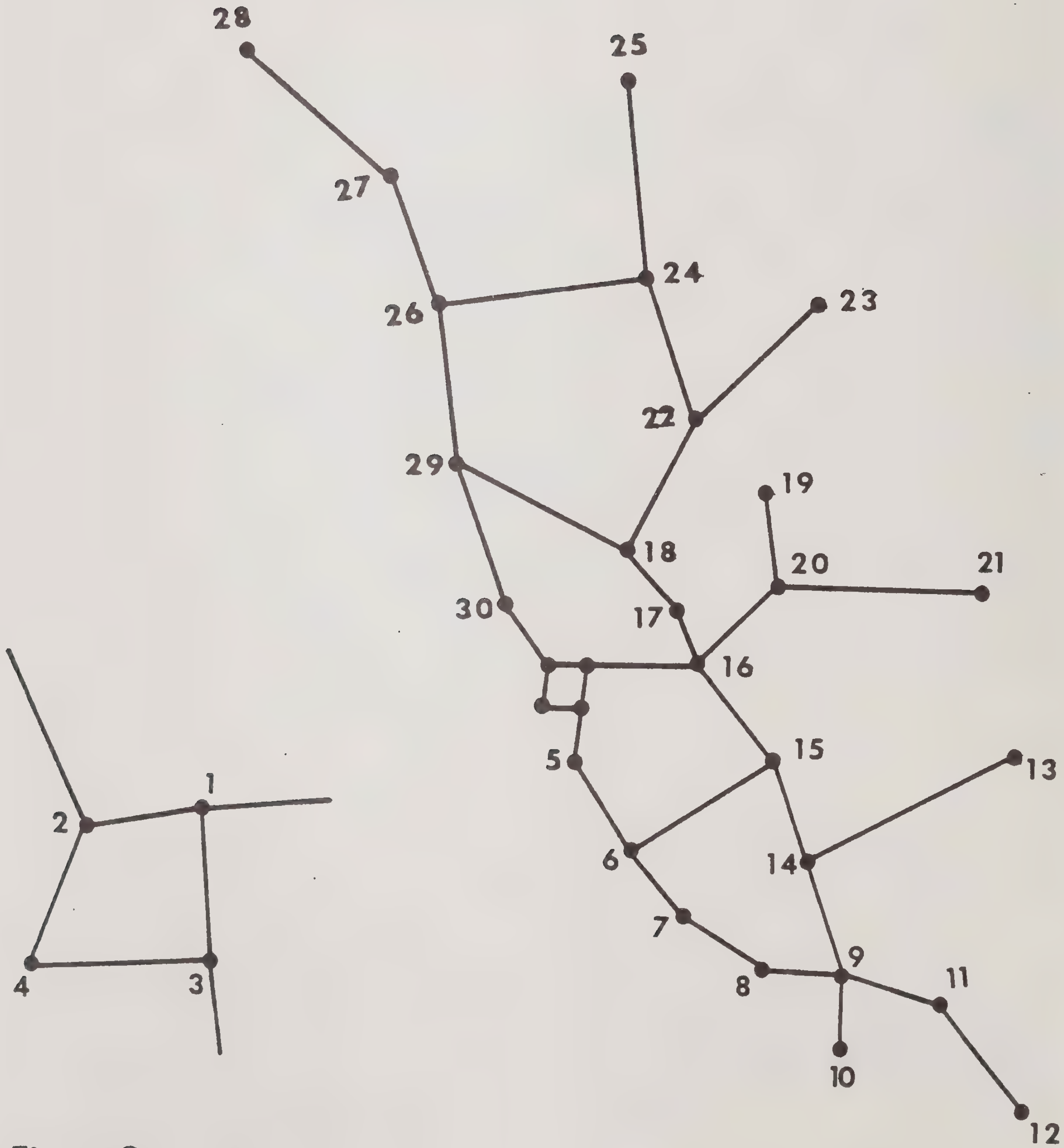


Figure 9
Hypothetical Transit Network

resulting traffic over each link is shown on Figure 10 for 1975 and Figure 11 for 2000 CLU. From these figures an attempt was made to determine the number of buses, transit cars, etc., needed to satisfy demand on each link. Although in practice different types (modes) of transit service are available between districts, only one mode was considered for most links in the system. The exceptions to the above generalization were the links between districts 1 and 3 and between districts 3 and 5. Between districts 1 and 3, the demand was served by BART, MUNI Metro and Southern Pacific. Between districts 3 and 5 transit demand was served by Southern Pacific and Urban Express Bus. In accordance with recommendations of the PENTAP Study, Southern Pacific was assumed to have a peak-period capacity of 11,700 in 1975 and 15,000 in 2000. All other modes were assumed to adjust the number of cars or buses to meet demand. The mode assumed for each link is shown in Figure 12.

Given the service characteristics of the modes, the level of demand and the approximate distance between modes, it is possible to estimate the number of cars (BART or Metro) or buses (express or long distance) required to service demand on each link. A comparison of the required equipment provides a general indication of the additional capital expenditure required to serve inter-district travel. It should be emphasized that these figures are gross estimates of the minimum equipment needed. The total number of additional buses and cars required to service inter-district peak period transit demand in the year 2000 is: BART - 60, Metro - 50, Buses (both long distance and urban) - 200.

No figures are given for Southern Pacific because it was assumed that the present service and capacity would continue largely unchanged. Because of differences in speed, distance, and distribution patterns, a different approach was taken for the analysis of intra-district trips. The speed for such trips vary between 4 mph for Cable Cars in San Francisco to 16 mph for buses in Oakland. Similar differences exist in the average trip length, number of stops per mile, route structure and type of service offered. The additional equipment needed to serve an incremental increase in demand is dependent on a number of characteristics particular to each district. Because it is not possible to account for each of these factors, a less demanding analysis was undertaken. The overall increase in travel by transit (during the peak period) was studied for each district. The districts were then roughly grouped together by transit operator serving the district. It was not possible to give a more exact indication of the increase in transit usage expected for each operator because the districts usually encompass a larger area than that served by a particular operator. These increases for each transit operator as shown in Figure 13 apply only for trips within each district; the corridor or inter-district trips were accounted for in the previous analysis. Therefore, the additional equipment needed as suggested by these figures would apply only to equipment used for the collection and distribution of traffic within each district. This in turn suggests that the application of additional equipment suggested by these figures should be in the feeder/distribution operations of the different operators. The expected ridership increase for the different operators are: AC Transit - 20%; GGBHTD and Sonoma County local transit operators - 40%; MUNI - 10%; SamTrans - 70% and SCCTD - 170%.

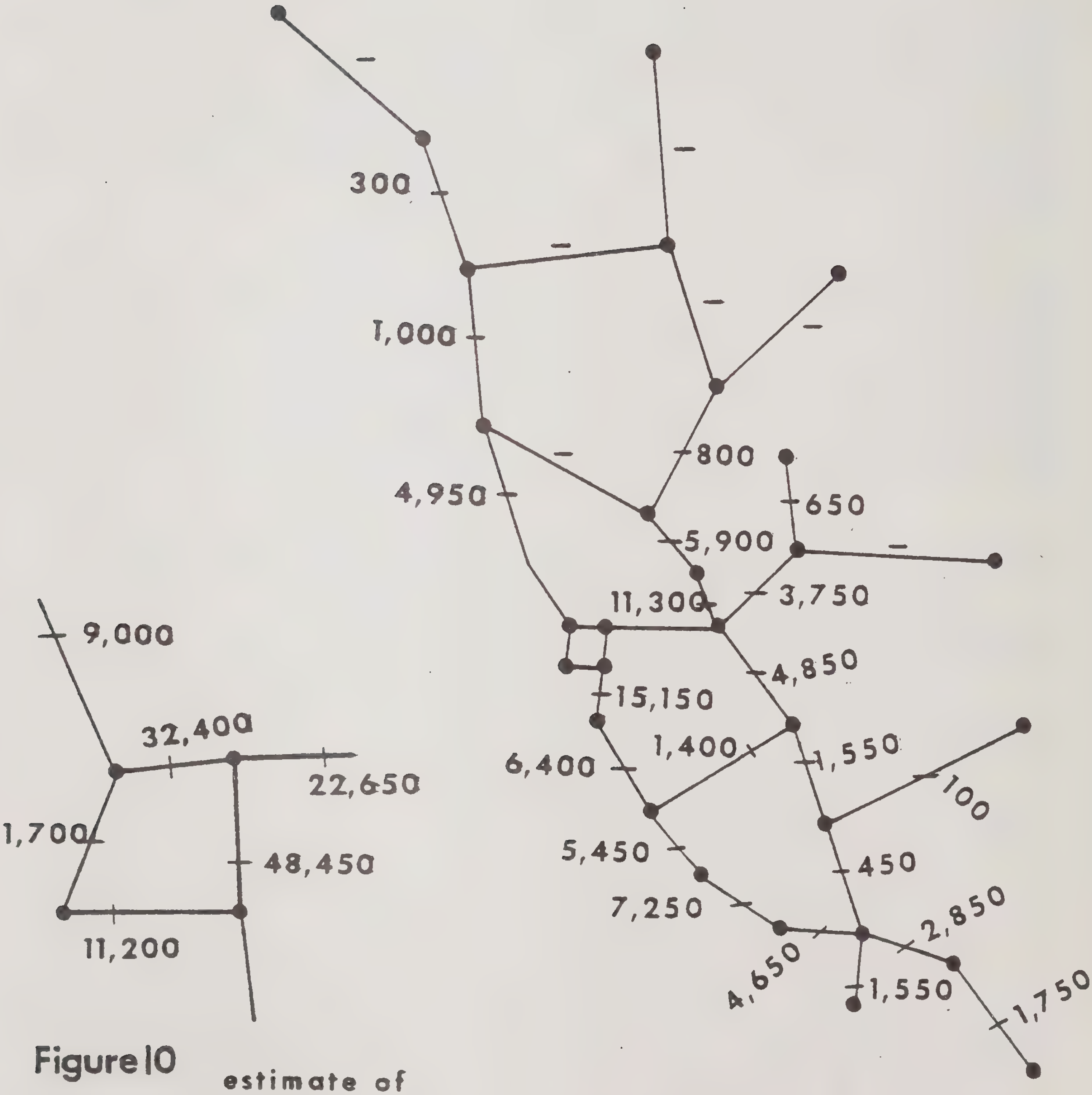


Figure 10 estimate of
1975 Inter-District Transit Traffic
During AM Peak Period

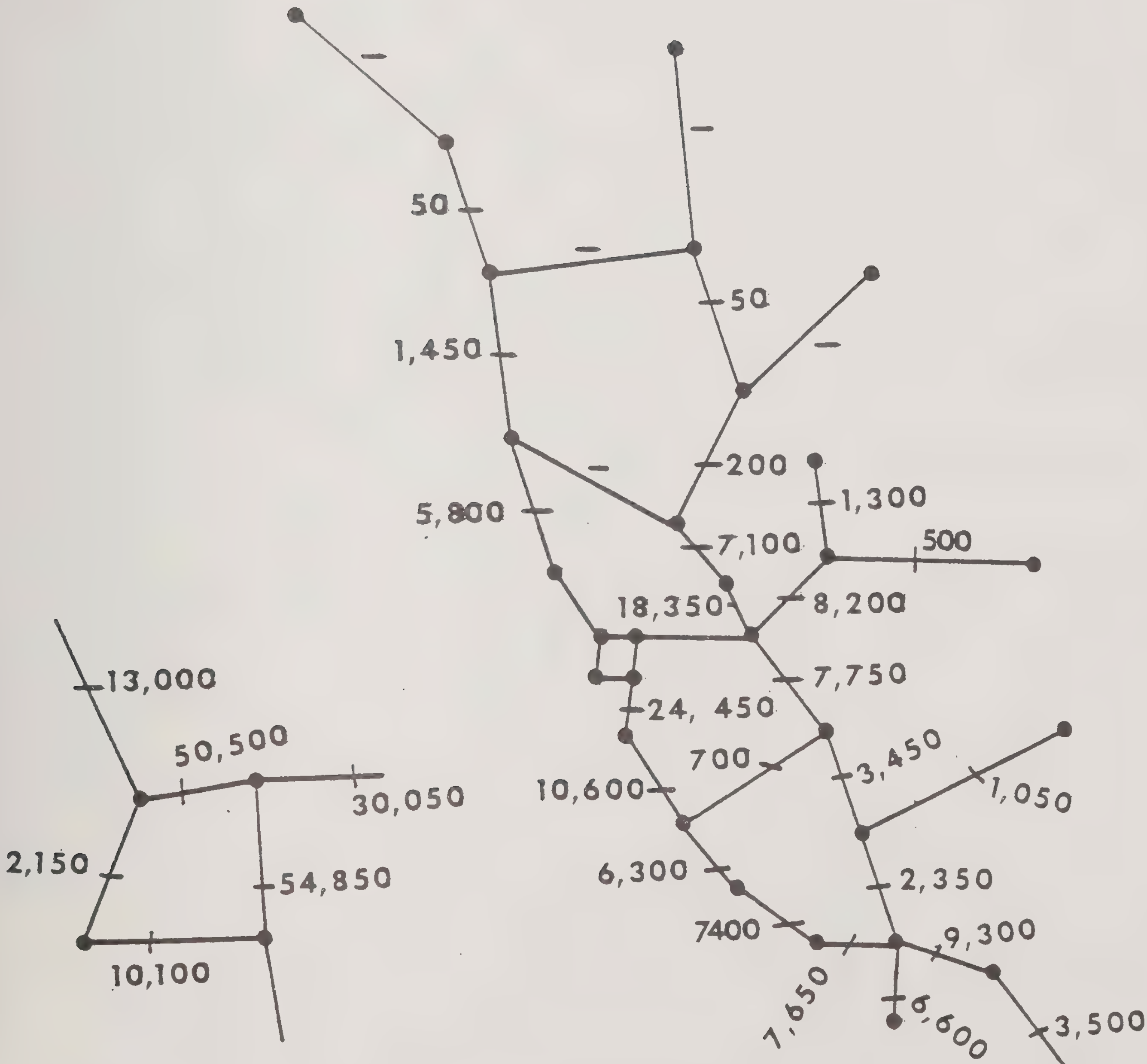


Figure 11

2000 Compact Land Use

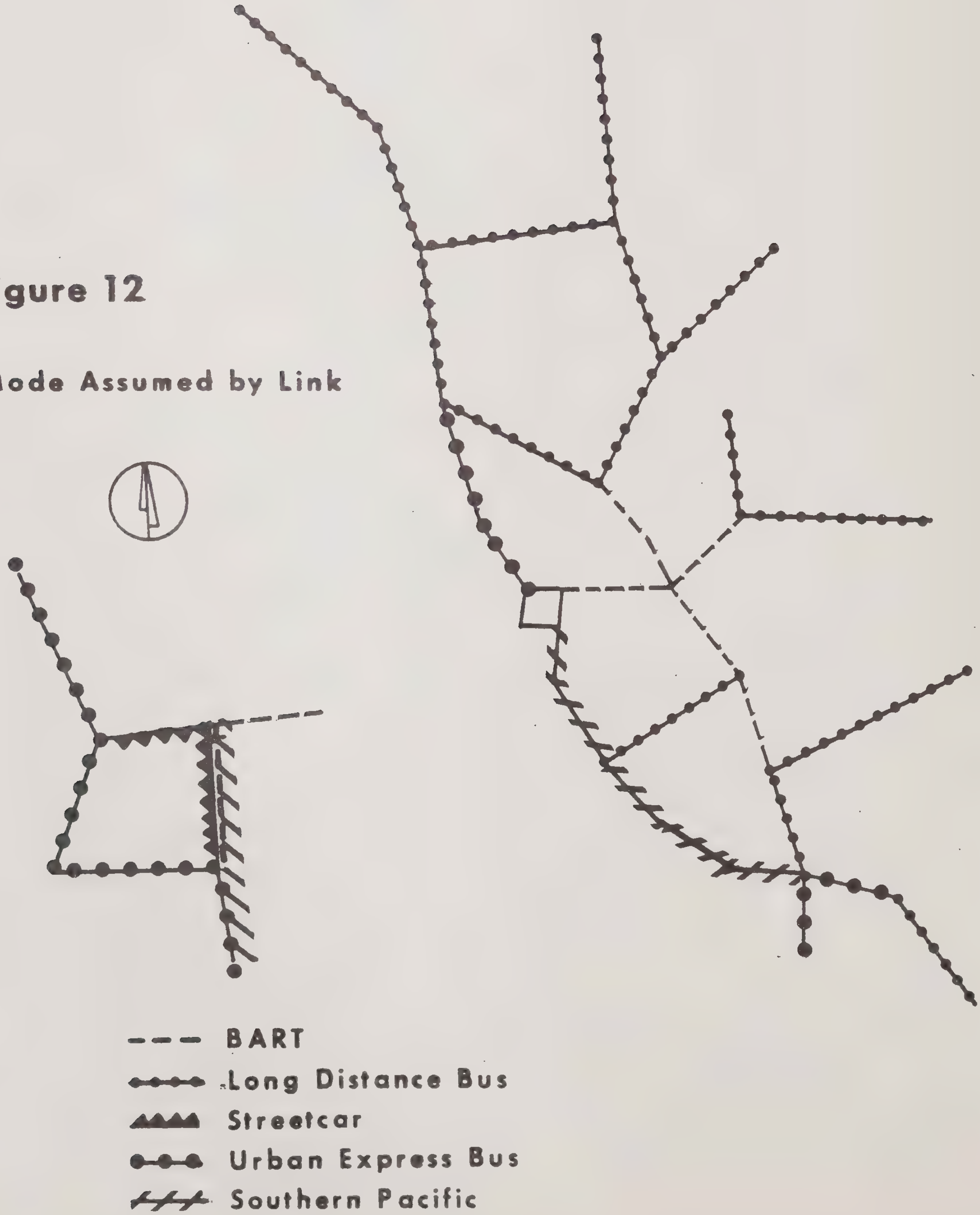
estimated

Inter-District Transit Traffic Traffic

During AM Peak Period

Figure 12

Mode Assumed by Link



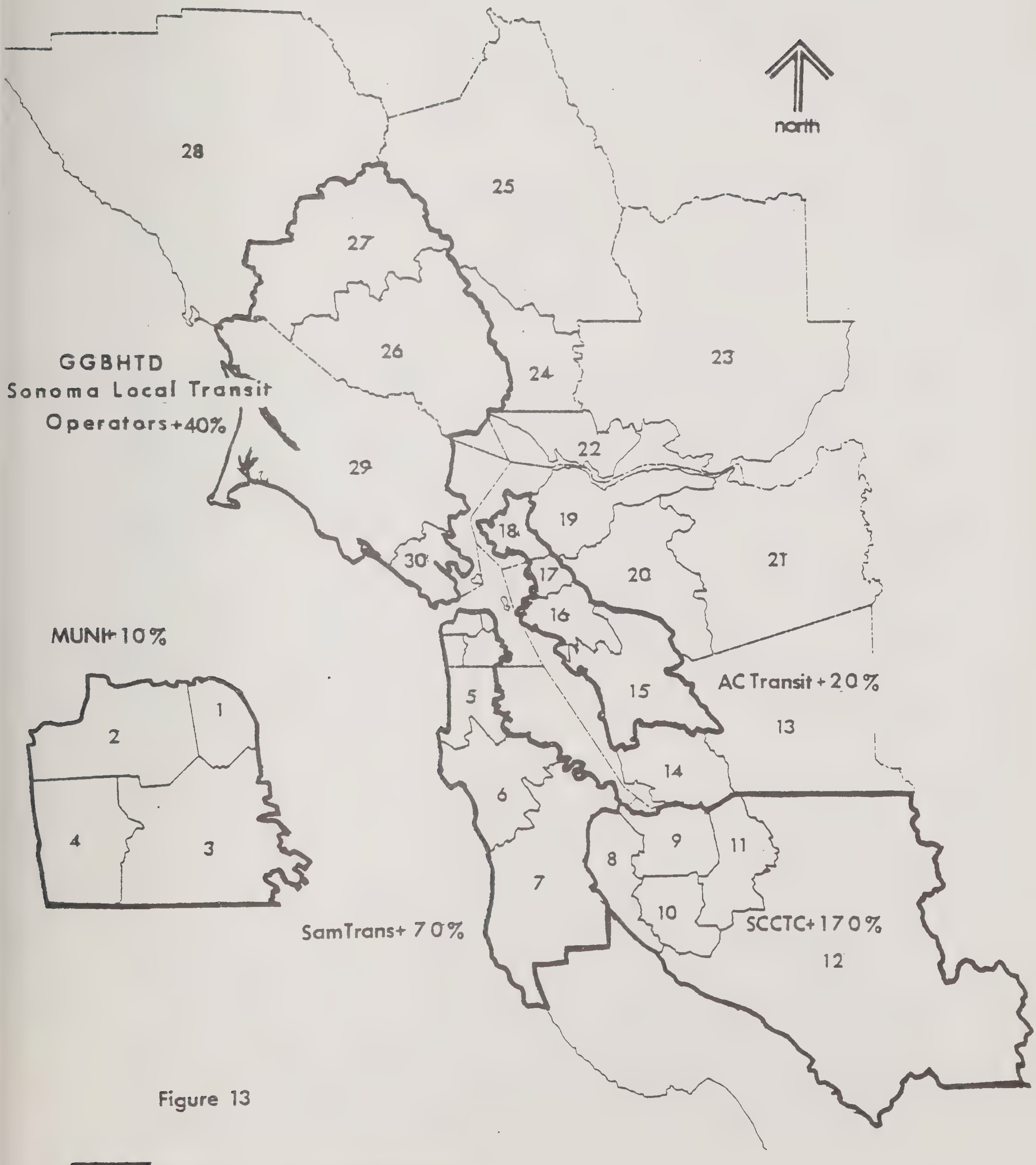

north
28
25
27
26
24
23
GGBHTD
Sonoma Local Transit
Operators+40%
22
29
19
18
21
30
17
20
16
MUNI+10%
1
2
4
3
5
15
AC Transit+20%
13
14
6
9
11
8
7
10
SamTrans+70%
SCCTC+170%
12

Figure 13

AQMP/Issue Paper 1/September 1976*

Air Quality Modeling for the San Francisco Bay Region

Issue Paper No. 1

September, 1976

The air quality maintenance plan (AQMP) being prepared for the Bay Area will be the latest in a series of air quality plans for the region. These plans have included the State Implementation Plans, the transportation control plans, and parking management plans. A major shortcoming of these previous plans was the use of an aggregated emission inventory and "linear rollback" technique for evaluating the impact of various controls on air quality. The technical validity, legal basis, and public acceptance of such an approach frequently undermined any proposals for more air pollution controls. The need for improvement in the technical approach of future air quality plans is clearly recognized. There now exists a wide variety of air quality models which may be applied to describe the Bay Area problems, and assess the impact of alternative solutions. An important issue is which model(s) is most appropriate. Once the models are selected, input data can be developed to meet specific model needs. The purpose of this paper is to provide a rational basis for model selection. It is not intended to be a generalized review of air quality modeling; such information can be obtained from the reviews cited in the text.

Physical Factors for Model Selection

Two basic physical factors determine the extent of the Bay Area's air quality problem. First, there is the emission of many different pollutants, each having a unique set of source types and distribution. The pollutants of concern are photochemical oxidants, carbon monoxide, particulate matter, and sulfur dioxide. Carbon monoxide and sulfur dioxide are primary pollutants with strong individual sources (e.g., automobiles, power plants), which frequently result in localized air pollution problems. Models for these pollutants need relatively fine spatial resolution. Photochemical oxidants and the photochemical aerosol portion of the total suspended particulates are secondary pollutants, and generally cause regional air pollution problems. These problems will extend beyond the urbanized portion of the Bay Area, and perhaps beyond the nine-county region. Models for these pollutants need less detailed spatial resolution, but accurate simulation of chemical reactions and pollutant transport.

*prepared with the assistance of the California Department of Transportation

TABLE 1. Representative Inventory of Air Quality Models

Model Developed by	Name	Applications
DETERMINISTIC-Gaussian plume		
U.S. EPA	PTMAX, PTMTP	major point source
U.S. EPA	HIWAY	highways
U.S. EPA/TRW	CDM/AQDM	urban SO_2, part.
Stanford Research Institute	APRAC-1A	urban CO
CalTrans	CALLINE	highways
IBM (Shieh)	---	urban SO_2, part.
The Research Corporation	---	highways
Hilst	---	urban
BAAPCD	---	urban & major point sources
DETERMINISTIC-Lagrangian		
Argonne National Lab	---	highways, airport, urban
Lamb & Neiburger (UCLA)	---	urban CO
Aerovironment	---	highways
Pacific Environmental Services	REM	urban O_x, NO_2, HC, CO
General Research Corporation*	DIFKIN	urban O_x, NO_2, HC, CO
DETERMINISTIC-Eulerian		
Center for Environment and Man	---	urban CO
Lawrence Livermore Lab	LIRAQ (1&2)	urban O_x, NO_2, HC, CO
Systems Applications, Inc.	---	urban O_x, NO_2, HC, CO
Systems, Science & Software**	PICK	urban O_x, NO_2, HC, CO
Systems, Science & Software**	EXPLOR	highways
Science Applications, Inc.	MADCAP	urban O_x, NO_2, HC, CO
Science Applications, Inc.	Reactive plume model	major point sources

*Authors are now at Environmental Research & Technology, Inc.
**Authors are now at Science Applications, Inc.

Statistical Models (all urban scale applications

U.S. EPA	Appendix J Rollback	O_x
Larsen (U.S. EPA)	Larsen analysis/rollback	all pollutants
Trijonis	Joint probability dist./ rollback	O_x
Wilson (U.C. San Diego)	---	O_x
Friedlander/ Trijonis	Aerosol origin characterization/rollback	particulates, photochemical aerosol
Tiao, Box	various	O_x, CO

Sources:

Rossano, A.T., "A Critical Review of Mathematical Diffusion Modeling Tehcniques for Predicting Air Quality with Relation to Motor Vehicle Transportation," Washington State Highway Dept. Research Program Report 12.1, June 1973.

Thuillier, et.al., "A Review of Air Quality Modeling and Data Base Resources in the San Francisco Bay Area," report to the Environmental Management Task Force.

U.S. Environmental Protection Agency, "Applying Atmospheric Simulation Models to Air Quality Maintenance Areas," Volume 12 of Guidelines for Air Quality Maintenance Planning and Analysis, EPA-450/4-74-013, September 1974.

Wada, R., "A Critical Assessment of the Role of Computer Models in Air Quality Planning and Decision-Making," University of California, Los Angeles, June 1975.

Myrabo and Wilson, "Survey Statistical Models for Oxidant Air Quality Prediction," in Assessing Transportation-Related Air Quality Impacts, Special Report 167, Transportation Research Board, National Academy of Sciences, 1976.

The second factor is meteorological patterns. The meteorology of the Bay Area is extremely complex and highly variable in both space and time. Thus, the application of models which assume uniform or steady-state meteorological conditions should be considered only under very limited circumstances. Results from such modeling efforts should be interpreted with an understanding of the inherent limitations.

Inventory of Alternative Models

The number of air quality models is difficult to determine and depends on how one defines availability to the present AQMP effort. Table 1 lists models which could be applied to one or more aspects of the AQMP analysis.

The models are categorized according to their approach, i.e., statistical as opposed to deterministic. Within the deterministic category, the Gaussian, Lagrangian, and Eulerian approaches are distinguished. Statistical models use empirical data to derive a relationship between emissions and air quality. Deterministic models attempt to describe in mathematical terms the physical relationships between emission sources and various "receptor" locations. Gaussian plume models are relatively simple, and assume both uniform and steady-state meteorological conditions. Such models cannot be applied to reactive pollutants such as photochemical oxidant. Lagrangian models "trace" a parcel of air or a puff of pollutant as it is carried by the wind across a given area. Space and time variability of meteorological conditions are included, with certain models focusing on chemically reactive pollutant species. Finally, Eulerian models define a fixed grid over a given area. Pollutant mass is passed from one grid to another according to the wind field specified for each grid, as well as other diffusion and chemical reaction parameters. Eulerian models are generally the most sophisticated models, and focus on short-term (hourly) problems such as those presented by oxidants and carbon monoxide.

While most if not all of the models listed have been documented in the technical literature, there are a few models which may be considered more readily accessible i.e., either already in the posession of some member of the AQMP Joint Technical staff, or "on-line" at a computer facility directly accessible to the Joint Technical staff. These models are as follows:

- LIRAQ - The Lawrence Livermore Laboratory regional air quality model recently validated for the San Francisco Bay Area for photochemical oxidants and carbon monoxide. The model is currently being modified to address sulfur oxides and particulate matter as well.

- DIFKIN - General Research Corporation's model recently validated for the Bay Area by Stanford Research Institute for photochemical oxidants. The model will be updated in terms of its photochemistry by Environmental Research and Technology, Inc.

- APRAC-1A - Stanford Research Institute's urban carbon monoxide model originally tested in San Jose and available on the Environmental Protection Agency's UNAMAP system.

- CDM - The Climatological Display Model (a multiple-source, Gaussian plume model for sulfur dioxide and suspended particulate matter) also available on EPA's UNAMAP system.

- PTMAX, PTMTP, HIWAY - Various computer-coded forms of a Gaussian plume formulation. These models are also available on EPA's UNAMAP system.

- CAL LINE - The California Line Source Model, developed by Caltrans, is a Gaussian plume model of dispersion from highways. (Primarily applied to carbon monoxide.)

- BAAPCD Models - A group of Gaussian plume formulations tailored for application to major point sources and inter-county transport of non-reactive pollutants.

- Larsen analysis - A technique for using frequency distributions of air quality data and an assumed log-normal distribution to describe the mean, peaks, and variability of air quality at a given monitoring location. In combination with a linear rollback assumption, this analysis technique can be used to evaluate the effect of emission reductions on air quality in terms of the resulting frequency with which a given level (e.g., the air quality standard) is exceeded per year.

- Friedlander/Trijonis aerosol origin characterization - A technique for using data on the chemical composition of particulate matter samples at various locations to deduce the relative contributions of various source types to total particulate loading of the atmosphere at those locations. In combination with varying forms of linear rollback assumptions, this technique can be employed to evaluate the effectiveness of alternative control strategies for both primary and secondary aerosols.

In considering the advantages and disadvantages of applying the alternative models, a useful starting point would be to examine this latter group of models first, expanding horizons to other models only if the group is found inferior to other potentially available models or inapplicable to evaluating some special aspect of the Bay Area problems. Taken as a group, the set of "readily available models" appears to be quite representative of what is more generally available, and also has the advantage of relative ease of access and application.

Criteria for Model Selection

In developing a modeling policy, a variety of considerations are important:

- Technical validity - The models employed should be generally agreed to represent the state-of-the-art in air quality modeling. This is necessary to establish the technical credibility of the analysis.

- Contingency - Despite the high level of sophistication reflected in many of the models available, none can be considered to produce a definitive representation of the Bay Area's air quality. In recognition

of the uncertainties associated with any single modeling approach, as well as the significant potential for socio-economic impact of the AQMP on the Bay Area, reliance should not be placed on any single model.

- Cost - Clearly, as each additional model is applied, the amount of new information gained will decline and the overall cost of the modeling program will rise. Further, since implementation and validation costs for models are not small, those models already validated for the Bay Area have distinct cost advantages.

- Consistency - The set of models used should be such that a consistent set of interpretations of model results can be formulated. This means that a consistent set of emissions and meteorological data should be used for both baseyear and projection cases to be analyzed. Moreover, model calibrations and response to changes in emission patterns should also be consistent. The need for consistency in data bases and models for all aspects of AQMP analysis cannot be overemphasized.

Other factors could be elaborated upon here, but for developing a policy for model selection, these factors are the most important. Clearly, there are tradeoffs to be made between these factors in order to come up with a single set of models to be used.

It should be noted that technical validity has been expressed as a criterion rather than model accuracy. This is because none of the models has been in existence long enough to observe whether a model prediction has indeed come true. Even after a sufficient period has passed, it would be extremely difficult to determine accuracy because many other variables will have changed -- meteorological conditions will be slightly different, emissions will not be quite the same as originally projected, and techniques for input data collection and processing will have advanced. The validation analyses conducted for each model merely confirm that the models can replicate what has occurred in the past. Whether the models can then accurately describe what will occur in the future is an implicit assumption for which no adequate test has yet been devised, at least on a regional scale.

Under dynamic situations such as this, emphasis should be placed on precision rather than accuracy. The differences between these two concepts is subtle: precision refers more to how the calculations are made and whether all significant phenomena are accounted for, than the ultimate result. The technical validity criterion is thus a measure of precision rather than accuracy.

The cost criterion focuses more on staff and time resources required to implement a given model than on the computer costs associated with running the model. This emphasis is due to the fact that staff resource requirements are generally much more significant than the actual cost of running a given model.

Generally speaking, the Gaussian plume models and the statistical models are quite simple and inexpensive to both implement and run. Lograngian models are more sophisticated and more expensive. The ultimate in sophistication (and cost) are the Eulerian models. Depending on the situation, a Lograngian model can be more costly to run than an Eulerian model, so generalized cost estimates should be viewed with caution. The Eulerian models produce a great

deal more information than other modeling approaches have been programmed to do, which in part explains the greater costs. As an example, the LIRAQ-2 model requires the entire core capacity and several minutes of execution time on the CDC 7600, which translates to dollar costs of $600 to $700 per run. LIRAQ-1 requires roughly $40 per run. Gaussian models cost anywhere between a few dollars to as much as $100 depending on the application, and the same is approximately true of Lograngian models.

Recommended Modeling Policy

The recommended AQMP modeling policy has been derived from the nature of the available modeling approaches. Air quality models have been classified as being either stochastic (based on probability or statistical theory and empirical data) or deterministic (based on mathematical representations of the physical system). Stochastic or statistical empirical models have the advantage of being directly tied to historical air monitoring data (a feature which seems to be of consderable comfort to the legal mind), and the disadvantage of being limited to evaluating emission changes which occur uniformly over a given area. Deterministic models can theoretically assess the impacts of emission changes in both space and time, but uncertainties in virtually all aspects of model application have historically made subjective interpretation of model results more crucial than the results themselves.

The recommended modeling policy, therefore, is to select the most technically valid combination of models within each class for each pollutant and analysis scale of concern. This satisfies the technical validity criterion as well as the contingency criterion. Consistency problems can be minimized by applying the deterministic and statistical/empirical models in tandem to define the range of future air quality expected from a given strategy (or conversely, to define the range of strategies which can result in achievement and maintenance of the air quality standards). In other words, one accepts that because of their radically different formulations, the two different approaches will yield two different answers. This is a reflection of the technical uncertainties involved in air quality modeling, and is easier to explain as well as defend than reconciling different answers coming from two similar approaches.* Finally, costs can be minimized by using the same model for different pollutants, with appropriate modifications in each instance. The rationale for multiple application of the same model extends beyond mere cost savings, as will be explained in the next section. For the moment it is mentioned to indicate that cost is not necessarily a problem under the recommended policy.

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* For example, model "A" will prescribe an emission level which is necessary to achieving and maintaining a given air quality standard. Model "B" may prescribe a different level which happens to be higher (i.e., more lenient) than the level prescribed by model "A". If the two levels differ only slightly, then no further interpretation is required. If the two levels differ significantly, control measures prescribed to meet the requirements set forth by model "B" may be considered to be the minimum necessary to achieve and maintain the standard. Additional controls required to meet the specifications of model "A" can be identified along with their social and economic impacts, and submitted to the Environmental Management Task Force for deliberation.

The modeling policy thus outlined is reinforced somewhat by comments recently made by EPA's Assistant Administrator for Air and Waste Management, Mr. Roger Strelow[1]: ". . .EPA at this time is not ready to call for implementation plan revisions based on data obtained from mathematical models used to calculate air quality at specific locations. Immediate plan revisions should be based on demonstrated (measured) air quality only. . ." This apparent policy statement on the part of EPA would suggest that we should not bother with deterministic models. However, the AQMP must be acceptable to locally-elected officials as well as the public and private concerns in the Bay Area. Techniques based on measured air quality cannot be used to address questions related to spatial differences in air quality -- an issue over which there is substantial local concern. Moreover, the California Air Resources Board has given sanction to the use of LIRAQ for air quality maintenance planning purposes.[2] The "two-pronged" approach to modeling is therefore necessary to meeting the diverse requirements of those who will be reviewing the eventual proposed plan.

Recommended Models

The recommeded AQMP modeling policy leads to some straightforward conclusions regarding which models are most appropriate for oxidants and carbon monoxide. For particulate matter and sulfur dioxide, however, the situation is not as clear.

In the case of photochemical oxidants, there are two readily available deterministic models from which to choose, LIRAQ-2 and DIFKIN. The LIRAQ-2 model developed at the Lawrence Livermore Laboratory is quite representative of the state-of-the-art in oxidant modeling. It is comparable in stature to the Systems Applications, Inc. photochemical model, and has the advantage of being validated for application to the Bay Area. The model has been installed on the Lawrence Berkeley Lab CDC 7600 system and is now available for use. The model is most applicable to regional scale analysis, and was in fact designed for the Bay Area situation. In contrast, the DIFKIN model was developed over three years ago and represents an intermediate level of sophistication in both its meteorological and photochemical aspects. Based on the documentation and validation experience available for each model, there is little doubt that LIRAQ-2 is the more technically refined model, and hence the logical choice for oxidant.

Statistical models for photochemical oxidant are not as clearly differentiated. The basic model is the Larsen analysis combined with a linear rollback assumption. Improvements on this formulation (e.g., Trijonis' model) attempt to incorporate spatial considerations or avoid the assumption of a log-normal distribution of the data. Since all such attempts

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1 Environment Reporter, Vol. 7, No. 13, pg. 536, July 30, 1976.

2 Letter from William H. Lewis, Executive Officer, California Air Resources Board, to Dianne Feinstein, Chairperson of the Bay Area Environmental Management Task Force. June 9, 1976.

must in the end rely on some sort of rollback assumption, it seems of questionable value to attempt to refine the analysis beyond the basic form. The log-normal assumption while not perfect is a reasonable approximation under the circumstances.

In the case of carbon monoxide, the LIRAQ-1 model is the most appropriate for describing changes in the regional distribution of CO. This is because of the more realistic treatment of meteorological variables allowed by the Eulerian framework as compared with the Gaussian approach. The LIRAQ models in particular include a sophisticated technique for ensuring that the wind flow fields used by the model are mass-consistent -- a feature which is necesary for proper application of a model to a region as complex as the Bay Area. LIRAQ-1 is similar to LIRAQ-2, with the primary differences being omission of the photochemical subroutine and incorporation of a more precise finite-differencing scheme.

It should be noted that carbon monoxide exhibits spatial variations on scales of as little as one hundred feet. The grid structure of LIRAQ-1 is much too gross to resolve such variations, and it seems advisable to superimpose a fine scale Gaussian plume model such as SRI's APRAC-1A street canyon model, EPA's HIWAY, or Caltrans' CAL LINE on the LIRAQ-1 output at locations where high CO levels are expected to occur. For small scale, short time frame (approximately 1 hour) applications, the Gaussian formulation is as valid as any other, with the added advantage of simplicity. The selection of the sub-grid scale model can be postponed until the potential CO hot spots (if any) are identified.

The Larsen analysis in combination with a linear rollback assumption can be recommended for statistical CO analysis with reasonable confidence since CO behaves linearly in response to changes in emission level, and its source distribution is relatively diffuse.

In the case of deterministic models of particulate matter and sulfur dioxide, a number of problems arise. First, and perhaps foremost is that the Federal primary standards for these pollutants are based on annual and 24-hour averaging periods. (State standards as well as Federal secondary standards include shorter averaging periods in addition to the daily and annual.) Historically, the Gaussian plume models have been applied to SO_2 and particulate problems. Unfortunately, the use of such models on a regional basis and over relatively long time frames is highly suspect, particularly given the meteorological complexity of the Bay Area. LIRAQ-1 could conceivably be used to model a peak 24-hour (or shorter) period for both pollutants. The standards for annual average concentrations however must still be addressed via some other means.

For particulate matter, the Friedlander/Trijonis aerosol origin characterization technique in combination with a linear rollback evaluation is specifically designed for annual average conditions. This technique has been applied to the particulate problem in the Los Angeles region, and much of the groundwork performed for that study would be useful in the present context. In comparison with the alternative deterministic approaches, this statistically-oriented technique exhibits great promise for addressing the annual average standard for particulate matter.

In the case of sulfur dioxide, the annual average standard could be addressed by extrapolating the results of the LIRAQ-1 24-hour analysis to an annual basis via a Larsen analysis transform. Such a technique could also be used for annual average particulate matter as well; and it is not clear whether the LIRAQ-1/Larsen transform approach is better than the Friedlander/Trijonis approach.

What is clear is that a unified modeling system has emerged, consisting of LIRAQ and Larsen analyses for each pollutant. In special instances, such as the fine scale Gaussian modeling for carbon monoxide and the aerosol characterization for particulate matter, the basic modeling system can be supplemented with techniques more specific to the individual problem of interest. Adoption of such a unified system would assist in ensuring that all criteria for the modeling policy (technical validity, contingency, cost, and consistency) are satisfied.

Unresolved Issues

Specification of the modeling system to be employed is a first prerequisite to addressing the many technical problems which will arise during the course of AQMP development. In particular, the application of a deterministic model as the basis for evaluating alternative control strategies for photochemical oxidant has never been attempted in an operational (i.e., non-laboratory) sense. Further, the somewhat redundant, two-pronged approach to modeling is being recommended with little prior experience as to whether the perceived advantages will be of real significance two years from now. Subsequent technical papers will address these aspects of model application.

Finally, the implications of the modeling policy expressed here extend beyond the AQMP program to other programs in the Bay Area involving regional air quality assessment. While it is not the intent of this policy to preclude the use of other models for air quality assessment in the Bay Area, it should be clear that such models as well as their input data bases should be consistent with those adopted for AQMP use.

THE LAWRENCE LIVERMORE LAB REGIONAL AIR QUALITY MODEL (LIRAQ)

(The following description of the LIRAQ model has been adapted from MacCracken, M.C., "User's Guide to the LIRAQ Model: An Air Pollution Model for the San Francisco Bay Area," Lawrence Livermore Laboratory, December 19, 1975.)

Because of the complex atmospheric and chemical interrelationships that combine to determine air quality on an urban and regional basis, the use of sophisticated planning and analysis tools is necessary for developing the information that can guide in making decisions that will affect air quality. The set of computer codes, which together comprise the Livermore Regional Air Quality (LIRAQ) model, have been developed as an operational tool to assist air quality control agencies in tasks such as assessing the compliance of present air quality with Federal ambient air quality standards, evaluating the impact on regional air quality of various land use alternatives, and predicting the effect on regional air quality of new sources and postulated emission control strategies.

The LIRAQ model has been developed by the Lawrence Livermore Laboratory (LLL) with the support of the National Science Foundation (NSF) and in cooperation with the Bay Area Air Pollution Control District (BAAPCD), which has provided a detailed source inventory and much of the information needed to compare the numerical model predictions with observations, and is the initial user agency; and the NASA Ames Research Center, which has used its instrumented aircraft to gather data for model comparison with observation.

The LIRAQ model attempts to treat most of the important factors that determine regional air quality as a function of time. The region of initial interest, the San Francisco Bay Area, is characterized by both its complex topography and its changing meteorology. As shown in Fig. 1, the region has quite intricate geographic features, including numerous ridges, hills, valleys, the Pacific Ocean, a central bay, and major inland flats. Meteorological systems formed over the Pacific Ocean are influenced by the complex Bay Area topography to create complicated, temporally and spatially varying wind fields, and inversion base heights.* The model treats both the complex topography and changing meteorology on one of several available grid scales (1 km or greater) from which the user may choose to study a particular air quality problem. The model does not attempt to forecast tomorrow's air quality, because that would require the capability to forecast the regional meteorology, a formidable problem in itself. Instead, in LIRAQ, the meteorology (wind speed and direction, atmospheric transmissivity, and mixing depth) must be specified, either at measurement stations or by coordinates. Typically, this involves use of either real or hypothetical meteorological situations (based on sets of previously acquired meteorological observations) that may be expected to be similar to future weather patterns.

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* In the LIRAQ model, inversion base height is treated as being equivalent to the depth of the layer through which pollutants emitted at the surface become well-mixed.

Fig. 1. Topography of the San Francisco Bay Area.

The air quality region being studied is based on the boundaries of the Bay Area Air Pollution Control District and encompasses all or parts of nine counties (see Fig. 2).

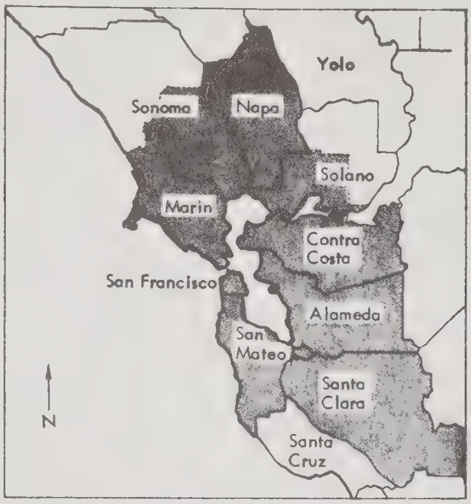


Fig. 2. Boundaries of the Bay Area Air Pollution Control District (BAAPCD).

Within the approximately 14000 km^2 of the BAAPCD, the emission of pollutants is spread in a non-uniform pattern over the region of interest. The model deals with four separate types of pollutant sources:

- Mobile (using emissions derived from a traffic model that represents the Bay Area traffic network using about 13,600 highway links and simulates hourly loading).

- Point (based on a compilation of major point sources from the BAAPCD with an hourly emission cycle and differentiating between surface and elevated).

- Airport (treated as limited-area surface sources with estimated hourly air traffic loading).

- Area (based on a distribution of estimated emissions* in proportion to 1970 U.S. census tract population distributions).

The pollutant species of interest in studying the regional air quality in the Bay Area can be divided into primary and secondary species. The primary species (meaning those which have identifiable anthropogenic sources) that the LIRAQ model can treat are carbon monoxide (CO), nitric oxide (NO), and hydrocarbons (HC). Based on the particular reaction set used in this model to treat photochemical air quality, hydrocarbons are divided into three characteristic types based on their reactivity: HC1 (mainly alkenes), HC2 (mainly alkenes, simple aromatics, ethers, alcohols, etc.), and HC4 (mainly aldehydes, some ketones, some aromatics). In addition, secondary species (those created through chemical transformation processes in the atmosphere) including ozone (O_3), nitrogen dioxide (NO_2), and others must be and are treated by the LIRAQ model.

* For the Bay Area, this is computed by estimating the total stationary emissions from such data as fuel usage, and subtracting the contributions from specified point and airport sources.

Because of the complex and non-uniform characteristics of the Bay Area (and to some extent of every region) and because a regional pattern is needed instead of a measure of air quality at a specific point, the mathematical approach that has been used is based on the establishment of an Eulerian (fixed) grid in the two horizontal dimensions. Options for a grid size of 1, 2 and 5 km are available over most of the area of interest shown in Fig. 3. All variables and locations are specified in the Universal Transverse Mercator (UTM) grid system. Because the depth of air through which pollutants mix is highly variable in space and time and in addition may intersect topography, the model has had to be limited to treatment of a single layer in the vertical. The height of this layer, however, may vary in space and time.

The LIRAQ model is thus capable of simulating the time- and space-varying concentrations of non-reactive and reactive pollutants on a regional basis using prescribed meteorology and source emissions. The basic types of questions that the model has been designed to deal with can be divided into three categories:

- Assessment of present air quality: By inputting to the model the present regional pattern of source emissions, the air quality on several specific days can be simulated. While observations from various measurement systems do provide an indication of present air quality at a few points (observations with which the model results may be compared), the model also indicates what the air quality is at locations between such observation sites. Such results may thus point to regions where more extreme air pollutant concentrations may prevail than are being measured. Such information may then assist in locating monitoring stations or indicate where mobile measurement stations should sample.

- Development of emission control strategies: For regions which do not meet the Federal air quality standards, the development of emission control strategies is an important consideration. A variety of model simulations may prove useful, depending on the time and spatial scale of the problem. One application might be to determine the relative role played by various types of sources - mobile, point, airport, and area - in degrading regional air quality. Another subject to investigate might be the relative importance of various species, as for example the importance of hydrocarbons with different reactivities. With such information, control strategies could be proposed and their effect simulated in order to determine the sense and magnitude of the effect.

- Planning for future air quality: Although control of emissions is the primary way to improve present air quality, proper planning of the locations, extent, and mix of future pollutant emissions is believed to be useful in assuring that future air quality meets appropriate standards. More specifically, the effect on air quality of a proposed source of

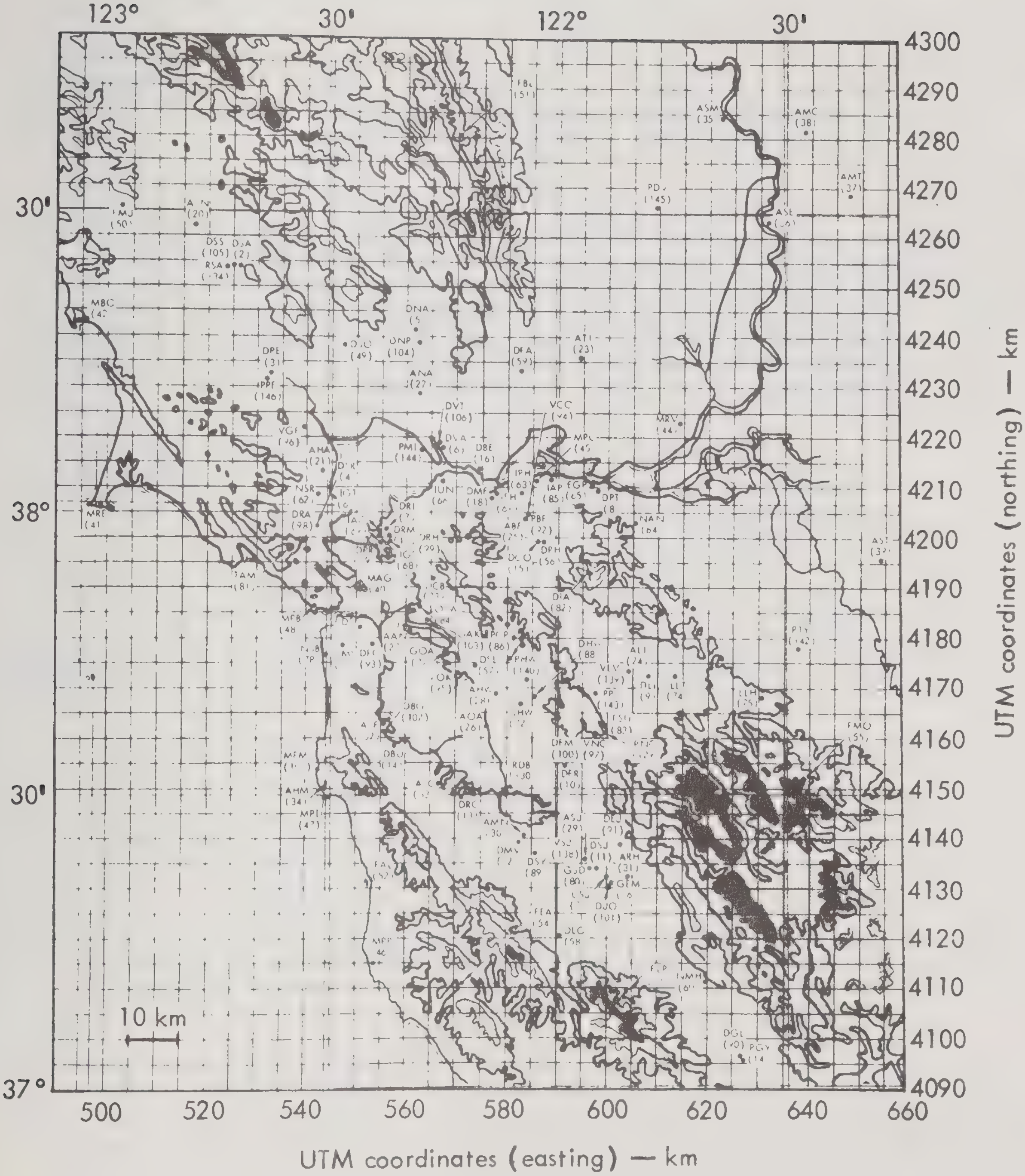


Fig. 3. Outline of the region of interest in the Bay Area that can be studied using LIRAQ.

subregional significance can be investigated if the pollutant emissions can be hypothesized. In addition to investigating land use, planning aspects of air quality and planning for potential changes in fuel usage can be undertaken; for example the potential effect of substituting methanol for gasoline or fuel oil for natural gas could be simulated, again if emission data can be specified.

The range of problems that are being addressed by air quality planners is very broad. The LIRAQ model, as outlined above, has been designed to treat problems of subregional and regional significance on spatial scales of more than a kilometre and time scales upwards from about an hour. Because of assumptions made in its development, both intentionally and induced by limitations in our knowlidge of the physics and chemistry of air quality, there are certain types of problems for which the model is not presently suitable. These include:

- Air quality problems resulting primarily from and close to (less than several kilometres) from major point sources (which may be more appropriately treated using Gaussian plume or other models).

- Air quality problems close to intense line sources such as highways.

- Air quality problems affected by the presence of major buildings or obstructions (e.g., street canyons).

- Air quality problems resulting from emissions from natural sources, unless they are included in the source emission information.

- Air quality problems affected by species not presently treated in the model (e.g., sulfur oxides, aerosols).

- Air quality problems that depend strongly on distribution of pollutants in the vertical (e.g., effects of varying stack heights).

To use the LIRAQ model, the user must provide input indicating what problem is to be undertaken. Most problems require only interactive teletypewriter contact with a special problem formulation processor code in order to input the relevant information. For some problems, however, the set of data files available to the user may not be adequate, and more involved interaction with the various input components may be needed.

THE LARSEN/ROLLBACK MODEL

Introduction

The Larsen-rollback model is the merging of two concepts -- the Larsen Model and the rollback. The Larsen Model was developed by Dr. Ralph Larsen of Environmental Protection Agency (EPA).

Essentially, it is a statistical model for estimating air quality for various averaging times. The rollback methodology is based on the concept that concentrations are proportionally related to emission rates. Combining the two concepts together, we have an analytical tool that can be used to assess the compliance of present air quality with Federal ambient air quality standards, to develop emission control strategies, and to predict the effect on future air quality.

Larsen-Rollback Model

It is necessary to estimate air quality in an area for various averaging times since Federal ambient air quality standards are set in terms of averaging times. For example, the national standard for carbon monoxide for a one hour averaging time is 35 ppm, and 9 ppm for an 8-hour averaging. The Larsen-Rollback model provides a mathematical basis for estimating air quality values for various averaging times. In combination with the roll-back concept, future years' ambient concentrations can also be estimated.

The Larsen-Rollback model consists of three primary characteristics:

1. Air pollutant concentrations are lognormally distributed for all averaging times. That is, graphically when plotting the logarithm of the observed concentrations versus its corresponding frequency, the resultant graph has a bellshaped (normal) curve.

2. Maximum concentrations are approximately inversely proportional to averaging time raised to an exponent. Mathematically it is stated as follows:

$$C_{max} = K \cdot t^{q},$$

where C_{max} = Maximum concentration,

k = proportional factor,

t = averaging time,

q = an exponent that measures the variability of the pollutant caused mainly by meteorology. (This variable can assume different values depending on the distribution of sources and the meteorological conditions in the vicinity of a given monitoring station.)

3. The Mean concentration is proportional to the amount of pollutant emitted. This is the linear rollback concept. Stated mathematically,

$$C = C_b \frac{ef}{eb},$$

where, C = future year concentration,

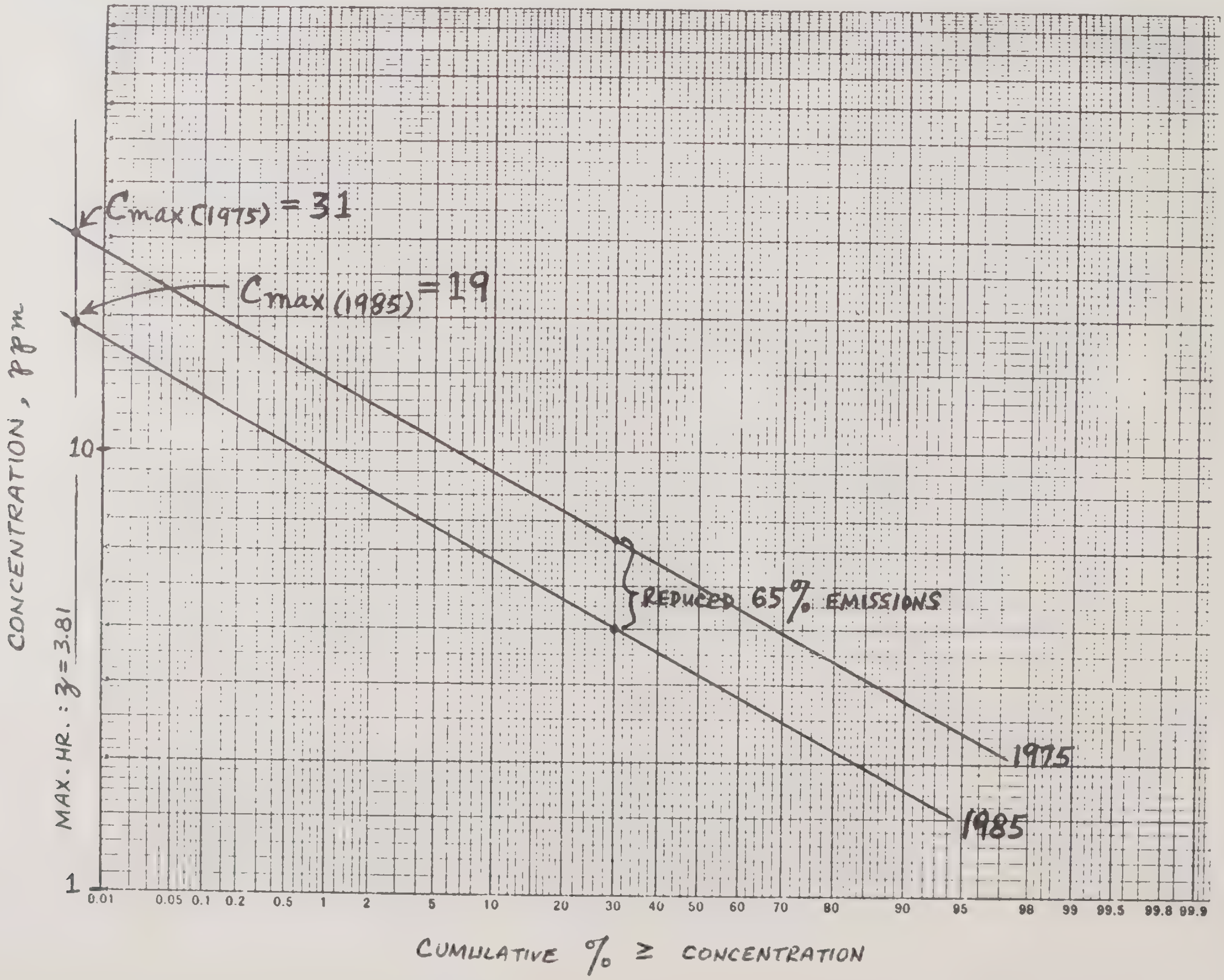
C_b = base year concentration,

ef = future year emission level, and

eb = base year emission level

Illustration

To demonstrate how the Larsen-rollback model applies to estimate future pollutant concentration level, we can show it graphically. Suppose we wish to predict the ambient concentration in 1985 for a certain area. Utilizing model characteristic (1) (observed pollutant concentrations are lognormally distributed), we can plot the 1975 base year sampled concentrations on special graph paper called the lognormal probability paper as shown in Figure 1 below:



Concentrations (ppm) are the vertical log scale and the horizontal scale is the cumulative frequency (the percent of observations greater than concentration value). A best fit straight line is then drawn through the data, and then extended to the percentile representing a frequency of occurrence of once per year. The pollutant concentration corresponding to this point is the expected maximum concentration level for base year 1975 (C_{max} = 31 ppm). The 50% percentile mark of the line is called the geometric mean, and the slope of the line is called the standard geometric deviation. The former is related to source strenght and the latter is a function of the meteorology and is relatively constant over the years. The 30 percentile mark of the graph (the mean concentration) is proportional to emission from base year 1975, then the 1985 were reduced 65 percent from base year 1975, then the 1985 line to the same percentile point representing a frequency of occurrence of once per year as for the 1975 level, and the concentration corresponding to this point is the expected maximum concentration for 1985 (C_{max} = 19 ppm) in that region of interest.

Similar procedure can be used to estimate other future years' expected peak pollutant concentrations.

Model Applications

There are three important areas in which the Model can be applied. They are:

1. In assessing present air quality - Depending on the pollutant, air quality can be estimated for areas of varying size ranging from subregional to the whole Bay Area. It gives expected maximum concentrations for one, eight, 12-hour, and other averaging times. It also gives an indication of the number of violations of a given air quality standard occurring in an area during the course of a year. These results provide definite indications of what present air quality is an their levels for standard comparisons.

2. In developing emission control strategies - This Model can be used to calculate the percent emission reduction required to meet the Federal Air Quality standards.

3. In planning for future air quality - As shown in the previously outlined illustration, this model can give an estimate of future years' expected pollutant concentrations. This capability is quite important to future planning applications.

Conclusion

This Model is quite flexible and workable for a wide range of subregional and regional applications. It has the capability of short and long-term forecasting. The operational cost is minimal as compared to simulation models, and the basic data requirements are few -- requires the base year's frequency of pollutant concentrations, and source emissions for the base year and prediction years. The primary constraints on the Model are that (1) it assumes that the meteorological conditions in prediction years are relatively similar to conditions in the base year; and (2) emission changes in future years must be assumed to occur uniformly throughout the area of interest.

In the particular case of photochemical oxidant, three additonal limitations or uncertainties are involved due to (1) the apparent departure of oxidant data from the standard log-normal distribution, (2) the fact that No_x emissions are neglected, and (3) the fact that oxidant is not expected to behave linearly in response to emission reductions. As serve as these limitations may seem the Larsen/rollback model is a generally accepted technique for defining control strategy requirements and/or evaluating the effectiveness of alternative strategies.

THE AIR QUALITY MODELING PROCESS: ACCURACY AND RELATED ISSUES

This paper describes the process by which air quality models will be applied and interpreted in the Air Quality Maintenance Plan. The main focus is on photochemical oxidant modeling, since this pollutant presents the most severe problems in terms of both modeling difficulties and anticipated control requirements. The proposed approach presented requires thorough review and discussion because it does represent a departure from previously accepted (but technically limited) methods.

To provide some perspective for evaluating the approach, it is necessary to describe a general modeling philosophy, and the process by which models have previously been applied to define emission control requirements. These descriptions are followed by the proposed modeling process for AQMP, and some general conclusions. The issue of accuracy and how it will be dealt with in assessing alternative control strategies is complex and requires more than a standard error analysis.

FRAMEWORK FOR MODEL APPLICATION

Models may be generally considered to be representations of our current understanding and information regarding a process. For photochemical oxidants, models are representations of current knowledge and data regarding the origins of precursor emissions, their transport and chemical transformation and their resultant distribution in space and time. Modeling facilitates the evaluation of complex problems by understanding each sub-component of the problem. These components are then assembled to study the problem in its entirety. (The whole is greater than the sum of its parts.) Models are thus vehicles for gaining understanding of complex relationships, such as are embodied in the photochemical oxidant problem.

Air quality models always have and will continue to contain inherent inaccuracies. This is a reflection of practical constraints on data acquisition, computer capacity, and the relatively unrefined state of knowledge on the complex processes involved. Unfortunately, air quality problems exist now, and the inaccuracies of a model cannot provide an excuse for inaction. To make rational control decisions which directly address ambient air quality standards established to protect public health and welfare, no viable alternatives can be identified to the use of air quality models. The more relevant and meaningful questions are: How will modeling results be translated into emission control requirements, and does that procedure provide a "hedge against uncertainty"?

The air quality implementation planning process is schematically summarized in Figure 1. The need for air quality models is a direct consequence of the definition of air quality goals in terms of ambient standards. Models serve as the bridge between ambient standards and source control requirements; they may be broadly defined as expressions of the relationship between source emissions and ambient air quality.

A second feature illustrated in Figure 1 is the continuing feedback and reevaluation of control strategies required as part of the planning process. This feature has been required in recognition of the dynamic nature of both air pollution problems and our understanding of how to deal with them. The key point is it is not necessary to specify the ultimate solution to the air quality "problem" via a single analysis undertaken at a single point in time. Indeed, the process has been designed with the recognition that it is not realistic to do so. This concept is fundamental in the AQMP modeling process described later in this paper.

PREVIOUS OXIDANT MODELING PROCEDURES

In the brief history of oxidant modeling for control strategy evaluation under the Clean Air Act, only two models have been sanctioned by the Environmental Protection Agency. These are the "Appendix J" rollback model and the linear rollback model. In either case the emissions/air quality relationship is simplistically displayed on a two-dimensional graph as shown in Figure 2. Using one of these rollback curves and knowing the highest or second highest one hour average oxidant measurement during a given year, one could infer the percentage control over hydrocarbon emissions necessary to achieve the oxidant standard.

The technical bases for both of these models suffer from major deficiencies. Among those deficiencies are the following:

- The role of NO_x emissions in the formation of oxidants is ignored.
- Varying photochemical reactivities for different organic compounds are ignored.
- The air quality effect of control strategies which result in non-uniform emission reductions over a given region cannot be evaluated (i.e. emission reductions must be assumed to occur uniformly).
- Rollback models have never been validated or verified.

These deficiencies and the relatively simplistic approach to the emissions/air quality relationship embodied in the rollback models have necessitated the development of certain key concepts. These concepts will be termed the "base year" concept, the "worst case" concept, and the concept of an "emissions target".

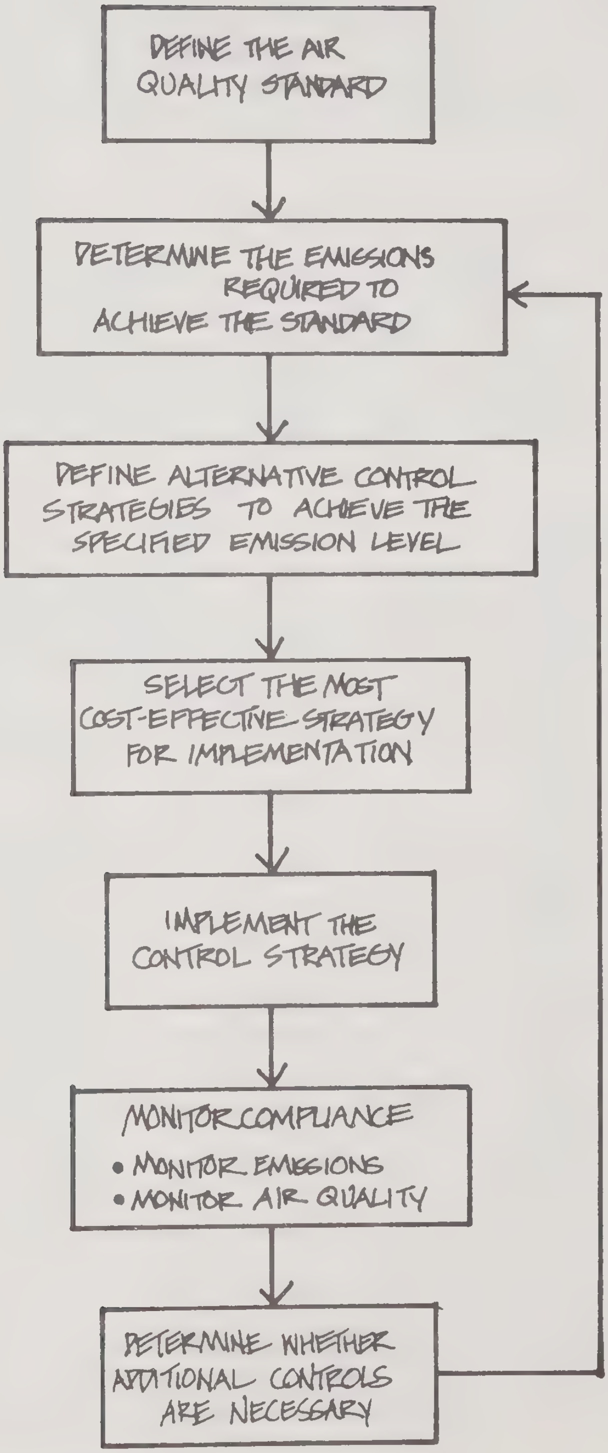


FIGURE 1. THE AIR QUALITY IMPLEMENTATION PLANNING PROCESS

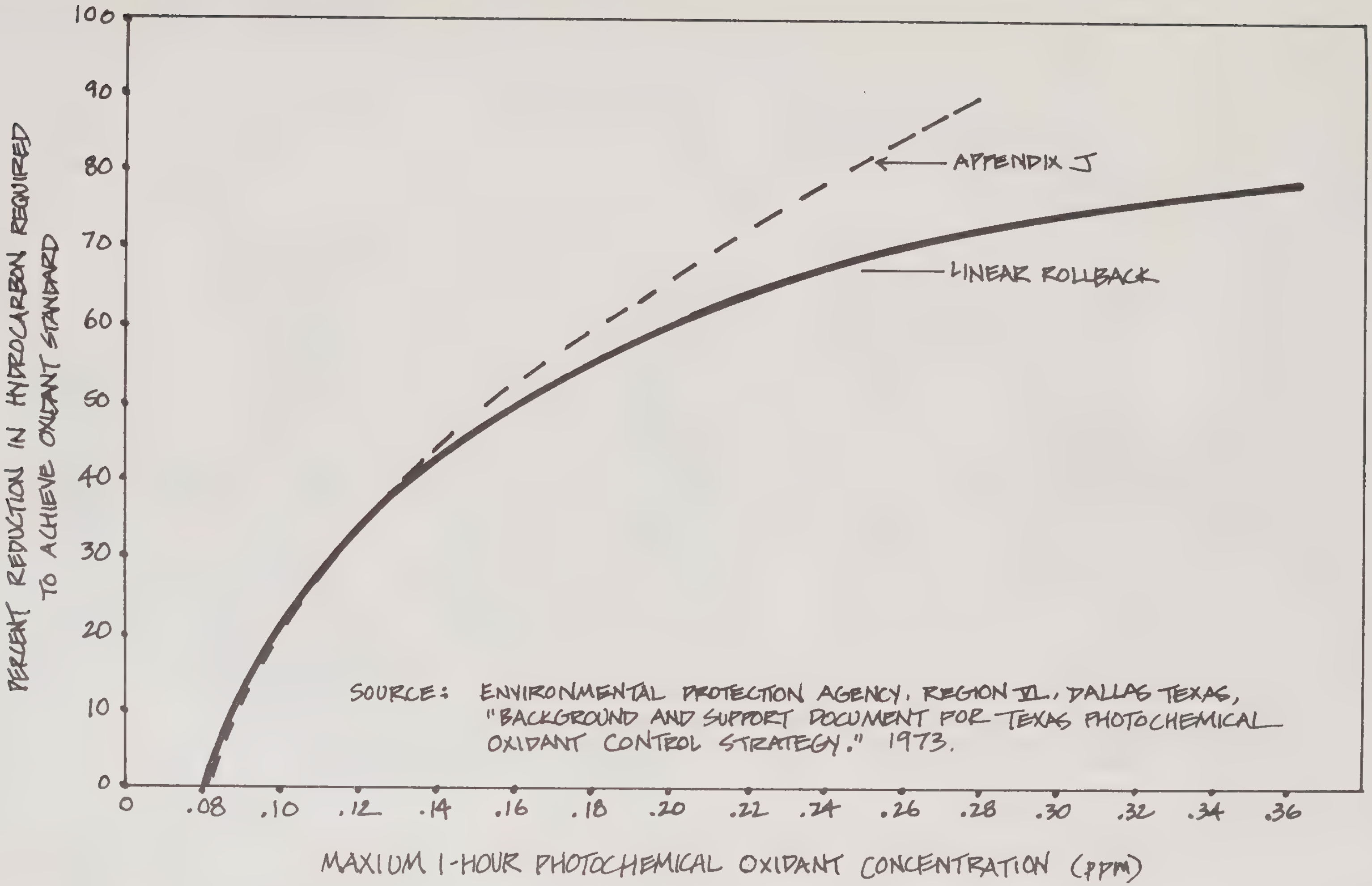


FIGURE 2 COMPARISON OF HYDROCARBON ROLLBACK MODELS

The Base Year Concept

In order to apply the rollback models, it was necessary to select a recent base year which, according to historical monitoring records, contained the highest oxidant measurements. The emission inventory for that year became the base from which rollback calculations were made. This specification of base year was made necessary because rollback is expressed in relative terms, and cannot be applied as an absolute predictor of future air quality.

The Worst Case Concept

The worst case concept was developed in response to the language in the Clean Air Act which specified that the National Ambient Air Quality Standards should not be violated more than once per year. Since the oxdant standard was set for a one-hour averaging period, this meant that the standard should not be violated for more than one hour each year. For air quality planning purposes, this also meant that the second-highest oxidant measurement during the base year should be used in the rollback calculation.[1]

Under this procedure, the incentive for local entities (both private and public) which did not wish to face severe control requirements was to discredit the high measurements as resulting from rare conditions or fluke events. In essence, the peak measurements to be used in the rollback calculation became an object of both negotiation and controversy, particularly since it is difficult to prove one way or another whether the rare conditions/events cited were really the cause of the high measurement.

The Emissions Target Concept, alias the Rollback Paradox

The output of the rollback calculation was a percentage reduction of hydrocarbon emissions required to meet the oxidant standard. By combining this with the base year emission inventory, an allowable emissions level (i.e., an emissions target) could be derived. The unfortunate aspect of this procedure is that the resulting emissions target is extremely sensitive to the assumptions made in the development of the base year emission inventory, and the particular peak oxidant level used. One particular manifestation of this sensitivity is the so-called rollback paradox. The paradox results because under the rollback calculation, the higher the base year emission inventory, the higher the resultant allowable emissions level is, and the lesser degree of control which is required to meet the air quality standard. Thus, by artificially inflating the base year emission inventory in certain categories, it was possible to reduce the severity of control requirements. Intuitively, one would expect that in the real world the opposite should be true. In fact, it may be seen that the rollback paradox is a direct result of the simplistic model and the simplistic procedure which were used to define control requirements.

[1] The California Air Resources Board interprets state air quality standards (10 pphm for oxidant) as "never to be exceeded". Hence they require that the highest measurement be used for rollback calculations.

The crux of the procedure to which attention should be focused is that: having set the emissions target on the basis of a single high hour measurement, control strategies were then designed to achieve the emissions target with no further consideration of air quality necessary (or possible). In short, it was assumed that on the basis of a simple calculation it was possible to prescribe the emissions target which will allow attainment and maintenance of the ambient air quality standard. This assumption was made necessary by the constraints set forth in the Clean Air Act. Basically, the State Implementation Plan must provide for attainment of the air quality standards by a given date (1977 for California), and maintenance of the standards thereafter. Unfortunately, the tools available to make such a determination were based on a poor scientific foundation.[1]

Presumably, amendments to the Clean Air Act currently under consideration by the Congress would provide a greater degree of flexibility in terms of attainment schedules. As will become evident in the next section, such flexibility is also crucial to the design of a rational modeling process for AQMP.

THE MODELING PROCESS FOR AQMP

The modeling process being developed to support the Air Quality Maintenance Plan is considerably more complex than the rollback procedures previously described. The model which is the primary focus of attention, LIRAQ, computes oxidant concentrations for selected days on an hour-by-hour basis, and at each location on a five kilometer grid covering the Bay Area. It has been designed to directly address those fundamental characteristics of the oxidant problem which are ignored by rollback models:

- The role of NO_x is explicitly described in a chemical kinetic model.
- Differing reaction rates for different classes of hydrocarbon compounds are explicitly described.
- Spatial and temporal aspects of the problem and of alternative controls can be evaluated.
- Partial verification is possible by simulating a number of days in the historical record.

In addition, a secondary or "back-up" statistical model will be applied which represents an independent, second method for acquiring the necessary answers. This model was developed by EPA and is currently being documented. Details will be reported when available.

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[1] The oversimplified procedures and the weight placed upon the procedures by the law led inevitably to a "numbers game" played between the various governmental agencies as well as between government and both public and private interests. It is the objective of the present planning effort to avoid such problems as much as possible by documenting technical methods and assumptions prior to completion of the analysis.

Before describing the process by which the two models will be applied, it is necessary to discuss key concepts associated with the use of deterministic models such as LIRAQ.

The Validation Day Concept

The LIRAQ model is a mathematical representation of the physical processes which lead to the formation and transport of pollutants with time scales ranging from a few minutes to a few days. This level of resolution means that instead of the base year required by rollback, a base or validation day is of greater significance. LIRAQ was tested (validated) on several historical days in order to verify that it could reproduce the oxidant levels that were measured on those days. Having been validated on specific days, it is then necessary to assume that the model can forecast pollutant concentrations under different emission scenarios using the same meteorological conditions which occured on the validation days.

The basic assumption is that the meteorological conditions which lead to adverse levels of air pollutants are recurring phenomena which are not expected to be changed in the future by long term trends. While this assumption is true in the sense that high pollution days have common characteristics, it may also be expected that no future day will ever be precisely the same as a past day. Since the precise characteristics of future days cannot be predicted, it must be assumed that the historical day(s) used are reasonably representative of what will occur in the future.

The Worst Case Concept

As previously stated, the worst case concept is the result of interpretations of language in the Clean Air Act, and the rollback models were designed to be responsive to this requirement. In attempting to apply the concept to the more complex LIRAQ modeling process, a number of difficulties arise.

First, there must be a mechanism for relating the historical day or days selected for modeling to worst case conditions in the future. From a technical viewpoint it is extremely difficult to predict the conditions which will lead to worst case oxidant levels, especially if future emission patterns will be significantly changed from existing emission patterns. The quantity and distribution of pollutant emissions in the Bay Area are expected to change dramatically during the time frame of the AQMP as a result of implementation of control programs, and overall regional growth patterns. Those conditions which led to worst case oxidant levels in the past <u>may</u> <u>not</u> lead to worst case levels in the future.

Second, the differences between "worst" case, "second-worst" case, and "third worst" case may not be solely due to differences in meteorological conditions. For example, quirks in the emission inventory for specific days are difficult to document and account for, hence the inventory used is simply a typical weekday emission pattern.

Third, the worst case for one monitoring location is not necessarily the worst case for other locations. To consider worst case conditions at all locations would require many more validation days (at least one for each location), with a concomitant spiraling of time and budget requirements.

These difficulties were not encountered under the rollback procedure because the rollback model was not sensitive to the various factors of concern. The worst case cannot be objectively defined for the LIRAQ model; instead, we must be satisfied to deal with reasonable representations of worst case conditions in order to be responsive to the provisions of the Clean Air Act.

The Emissions Target Concept

Because LIRAQ output is in terms of air quality parameters (concentrations of pollutants) there is no need to define an intermediate "emissions target." The effects of alternative control strategies on air quality can be tested directly, and because the effects of NO_x and differing hydrocarbon reactivities are included, it is probable that a number of different emission levels will result in the same peak oxidant levels. Thus, the concept of a single emissions target developed under the rollback procedure is no longer applicable. Emissions targets can be expressed in a variety of ways (different mixes of precursor emissions and different spatial and temporal patterns), each of which could result in attainment of the oxidant standard.

Interpretation of LIRAQ Output

The previous discussion has served not only to contrast LIRAQ modeling procedures with rollback modeling procedures, but also to illustrate that the more complex and realistic portrayal of air pollution processes also demands a greater level of sophistication to interpret precisely what is going on. Although LIRAQ does represent the state-of-the-art in air quality modeling, it is not a perfect model. The model will be used for "what if" forecasts of future air quality on typical poor air quality days, but should not be construed as predicting absolute air quality concentrations. On the other hand, the air quality standard which must be achieved is defined in very specific terms, and the analysis supporting the plan must identify the specific control strategy necessary to attain and maintain the air quality standards for the future years of interest.

An important issue is, therefore, how should LIRAQ output be interpreted to arrive at a judgment of whether a given control strategy will result in attainment of the air quality standard? Four potential methods for interpretation of LIRAQ output have been identified and are described in Attachment A to this paper. Each method has a different set of faults and merits, as described in the attachment. Before a decision can be made on which method is most appropriate, the remaining aspects of the AQMP modeling process should be described.

Incremental Planning for Air Quality Maintenance

There are two fundamentally different ways to go about planning. One way (which is the way previous air quality plans have pursued) is to assume that it is possible to prescribe the control strategy which will result in attainment of the air quality standards within a pre-specified time frame. While the Clean Air Act does not specifically prescribe this approach, this assumption was made necessary by the mandate set forth in the Act. It can also be generally agreed that such an assumption has resulted in much frustration over the brief history of the air quality implementation planning process in California.

The alternative planning approach, which is also ideally suited to long range air quality maintenance planning, is the incremental planning approach. Here we admit that air quality problems are extremely complex, and that there remains a great deal more to learn before they can be considered solved. A degree of uncertainty in the prescription of ultimate control strategies is inescapable and we must therefore proceed in an incremental fashion in evaluating and implementing each new control program. The incremental approach derives strong support from the fact that the cost of control escalates rapidly with each additional control increment. Thus, the last increment of control is both the least cost-effective and the most difficult to support in terms of the precision of the modeling analysis.

The significance of the incremental planning approach is that it does not demand total accuracy from the models used. It requires only that the models (1) point in the right direction, and (2) are precise enough to support implementation of specific additional control programs which will produce measurable improvements in air quality. This approach is not new in air quality planning, but the connection between the planning approach and the criteria used to judge the adequacy of models is often overlooked. Since the AQMP process has a built-in requirement for regular review and updating of the plan[1] (the continuing planning process), to require complete accuracy from the models used is unnecessary as well as unrealistic.

While the incremental approach is not responsive to the short time frames prescribed in the 1970 Clean Air Act, the amendments currently under consideration by Congress would provide the flexibility needed to make the approach work.

CONCLUSIONS

There are three key conclusions to be drawn from the preceding discussion. First, the concept of prescribing at a single point in time air pollution control requirements for the next ten or twenty-five years should be deemphasized. The two factors which have led to this conclusion are:

- The tools presently available are not refined enough to do this realistically.
- The AQMP process is being designed to be flexible to changing conditions. Air quality problems are dynamic in character, so that even if perfect analysis tools were available, continuing reevaluation of control strategies would still be necessary.

Second, the process by which model results are translated to control strategy requirements shares equal importance with the models themselves. This process, while including a purely technical input, cannot be a purely technical exercise. Staff and technical advisors can interpret model results, but in the end the subjective judgment of the degree of additional

[1]Current EPA guidelines specify a five year review and update cycle for AQMP. This schedule may be shortened if new information warrants such a change.

control to be pursued will be a political decision--made through the political process established as part of the AQMP. The continuing planning process will be designed to provide the necessary checks, reevaluations, and "mid-course corrections" as new information, new technology, and more refined analysis tools become available.

Third, the inaccuracies inherent in the models will be reflected in the plan. Because of the model's inherent inaccuracies, confidence cannot be placed in the air quality forecast for programs which produce small changes. Thus, control programs which are only marginally effective will not be supportable by the technical analysis. Based on the planning approach and the design of the AQMP process, the issue of accuracy should not be a significant impediment to the preparation of a viable AQMP.

ATTACHMENT A
ALTERNATIVE METHODS FOR COMPARING LIRAQ OUTPUT
TO AMBIENT AIR QUALITY STANDARDS

Four alternative means of interpreting LIRAQ output have been identified by the modeling sub-committee of the AQMP Joint Technical Staff. Although other options can be defined, these appear to be the most viable. The need for defining alternatives will become clear when the problems associated with each are described.

The alternatives can be divided into two categories: Those which use historical monitoring data to extrapolate LIRAQ results, and those which accept LIRAQ results "as is."

The underlying problem is that the existing days in the LIRAQ library (those days for which LIRAQ has been validated) are not the worst-case days according to historical monitoring data. In particular, the two high oxidant days in the library are July 26, 1973 and July 2, 1970. Maximum one hour oxidant levels recorded on each of these days were in the top ten for their respective years, as well as being in the upper 3-1/2 percent of the overall five year distribution from 1970 through 1974. In addition, the all-time highest oxidant level in the historical record for the decade of the 70's was recorded on September 13, 1971 at 29 pphm compared to 18 pphm on the two LIRAQ days. The second highest was recorded on June 30, 1972 at 27 pphm.

Option 1

The first option is to assume that the existing days in the LIRAQ library are reasonable representations of worst-case conditions, given the difficulties in defining precisely what worst-case conditions are for future years. The principal advantage of this option is that it is the most expedient in terms of completing the analysis on schedule. Additional days will be added to the LIRAQ library as part of the continuing planning process and additional control strategies can be developed as needed. The disadvantage is that the data would suggest that more adverse conditions than those contained on the existing days could be found. The initial AQMP would not present a complete picture of what future air quality would be under a given strategy.

Option 2

The second option would be to delay completion of the initial AQMP until a suitable worst-case day (or days) can be developed for LIRAQ use. Approximately three calendar months would be required for each day to be added to the library. The advantage is that a better representation of worst-case conditions will probably be developed, and hence the initial plan will be based on a firmer technical and regulatory foundation. The disadvantages are that a significant delay will be incurred in the program and the cost of producing the intial plan will escalate well beyond current estimates.

Even with the additional days, a judgment of whether worst-case conditions have really been represented will still be a matter of subjective interpretation.

Option 3

The third option employs a statistical distribution of historical days to determine where on the distribution the existing LIRAQ days lie. By knowing the position of the days according to the monitoring data, it is possible to perform an extrapolation of LIRAQ results for the existing days to determine an expected maximum oxidant level on the "worst-case day." Option 3 would use the maximum one-hour oxidant concentration calculated anywhere on the LIRAQ grid to characterize projected air quality for that day. The statistical distribution of days would be developed using the maximum one-hour concentration measured anywhere in the monitoring network.

This option provides a simple method for extrapolating LIRAQ output to "worst-case conditions." However, there are a number of conceptual problems with this method. First, by focusing on the maximum level as the measure of air quality on a given day, we throw away a great deal of the information being generated by LIRAQ. Second, since the maxima in the future will likely be displaced in both space and time from their original positions, it is likely that the position of a given day on a statistical distribution would also change. Since there is no practical means of determining such changes, it must be assumed that the distribution of days remains intact in the future. Third, portions of the region which may experience small increases in oxidant levels as a result of a given strategy cannot be accounted for.

Option 4

This option incorporates spatial considerations into the statistical extrapolation proposed in Option 3. In this case, LIRAQ forecasts of maximum oxidant levels at monitoring station locations only are compared with a distribution of monitored maxima at each station. (Each monitoring location is analyzed independently.) The primary problem with this option is that it must still be assumed that the distribution of days does not change as emission patterns change in the future. Secondarily, maximum concentrations forecast to occur between station locations are ignored, since there is no data at such locations which can be used to develop the necessary statistical distributions.

It should be noted that in Options 3 and 4, which use monitoring data to extrapolate model results, it is implicitly assumed that the monitoring data present a more accurate representation of air quality than the modeling data. Such an assumption has not been demonstrated to be valid.

It may be seen that there are problems associated with each of the four options for interpreting LIRAQ output vis-a-vis the oxidant standard. However, a regulatory determination must be made concerning the acceptability of the AQMP, and its compliance with the requirements of the body of existing laws and regulations. This interpretation of model results is a cornerstone to that determination. The AQMP Joint Technical Staff will decide on which option to use with the assistance of the AQMP Advisory Committee, and with whatever guidance can be provided by EPA and ARB.

AQMP/Issue Paper 3 September 1977

REGIONAL/LOCAL ISSUES IN LAND USE CONTROLS FOR IMPROVING AIR QUALITY

This paper reviews the process in which land use controls have been examined in the Air Quality Maintenance Plan. It reviews the background leading to air quality testing of an example "compact growth" land development alternative. That alternative is decribed in terms of specific measurements of land development and the effect on projected auto travel.[1] Finally, it includes as an appendix a complete listing of candidate policies and actions which could accomplish the air quality objectives examined in the example compact growth alternative. The listing includes the pertinent local, regional, and state agencies having appropriate responsibility for each action.[2] The policies and related actions can serve as a guide for selecting land use mechanisms in each jurisdiction appropriate both to air quality concerns and to other concerns, both environmental and developmental.

ISSUES

The fundamental issue involved in proposing land use controls for improving air quality is whose controls and how severely must they be applied? Can land use controls as carried out by local jurisdictions--for the most part cities and counties--do anything to improve air quality, or is intervention from the regional or state levels likely to be needed?

The analysis completed to date indicates that land use controls applied to the degree described in this paper can have significant effect in reducing auto usage and miles of auto travel as well as diverting a significant number of trips from auto to transit.

The land use controls as analyzed largely represent local jurisdictions applying controls already in effect in significant areas of the region with relatively little intervention by regional or state authorities. The basic difference from the Base Case representation of local agencies continuing along their present path is that certain controls would be applied more widely and specifically related to air quality. To be sure, some controls would also be applied more severely, notably higher density zoning. Also state and regional agencies may need to assist local agencies to achieve a regionwide balance of housing and jobs to reduce a significant amount of extreme long distance commuting. This could take the form of encouraging land development in a few northbay locations where local jurisdictions are prepared to support more development than current regional policy and trends would send their way.

All controls as described here would be applied as "packages" to achieve a more compact land development pattern to in turn reduce auto usage and miles of auto travel. The package applicable to each jurisdiction will need to be reviewed by local jurisdictions to determine if alternative policy/action packages might accomplish the same objectives while at the same time better addressing unique local non-air quality concerns. This is the essence of growth management programs already underway in many local jurisdictions.

BACKGROUND TO THE ISSUES

This section of the paper summarizes the background work leading to the package of land use controls documented here as they relate to the one example regionwide and development alternative described as the Compact Development Alternative. More detailed documentation of this work is referenced.

Existing Land Use Controls

Existing land use controls--termed local development policy instruments--were inventoried regionwide in ABAG's 1976 Local Development Policy Survey and documented briefly in other AQMP papers as they relate to air quality.[3] That inventory included techniques used by both service providing and regulatory agencies (special districts as well as cities and counties). It is important to note that these controls as inventoried and as proposed here for air quality objectives are specific legal and fiscal tools, such as zoning and capital improvement programs, which are used to implement the general plans of cities and counties as well as the service plans of special districts. The Local Policy Survey had two phases:

- A mailback questionnaire survey conducted by ABAG staff with the assistance of ABAG's Projections Technical Advisory Committee. (Summer 1976)

- A following interview survey conducted by county "208" lead agencies with ABAG staff assistance. (Autumn 1976)

Alternatives For Future Land Development

Regionwide land development alternatives have been under consideration by regional and local technicians for several months as part of the AQMP work program and also the ABAG Series 3 Projections program. The issues of local controls and regional intervention as related to one or more regionwide alternatives have been debated by ABAG's Projections Technical Advisory Committee (PTAC) and also discussed with a subcommittee of the AQMP Technical Advisory Committee.

A concept for structuring regonwide land development alternatives for ABAG's population and land use projections described the Base Case Projections and two alternatives (air quality "best case" and "worst case"). These two conceptual alternatives were discussed with both technical groups in the spring. They dealt with five key aspects of land development and how these aspects relate to actions of local and/or regional agencies:

- Timing of development - Frequently reflected in local general plans but seldom addressed in specific regulatory actions. Consider wider application by means of such measures as local growth sequence zoning; annual dwelling unit quota systems, etc. Some regional controls on timing of development might be necessary to achieve air quality standards.

- Quantity of development - Most often keyed to local service capacities. Presently scattered local application could be expanded through such measures as building permit or sewer/water hook-up moratoria as occasionally enforced by state and regional agencies.

- Location of development - Usually a function of sewer and water lines, annexation, and zoning. Control could be improved through regionwide coordination with other local land regulations, preserves, acquisitions, etc.

- Density of development - Regulated by local zoning for residential development, infrequently for non-residential development. Consider innovative density zoning mechanisms such as density bonuses, planned unit developments, etc.

- Type of development - Primarily regulated by local zoning. Consider better housing/job balance by encouraging localized land use mixture of residential/commerical/industrial development.

This concept for examining both "best case" and "worst case" air quality related land development alternatives is discussed in detail in an ABAG discussion paper and summarized in AQMP papers.[4]

Other Alternatives

Special note should be made of other alternatives considered which would not necessarily deal with all of the above aspects of land development, and are not examined for such details as the control measures or policy actions required to implement them. Hence they would not necessarily be pertinent to the issues of regional/local land use controls.

Slow Growth - An assessment of the long term effect on air quality of a slower rate of regional population growth. This would be the lower Series 3 Base Case projection (Base Case 2) without consideration of new land use controls. It would assume the same current operating policies on the part of local jurisdictions as the high Base Case projection (Base Case 1) which is being assumed as the air quality base line. The Slow Growth assumption has particular significance in combination with assumptions on transportation controls and motor vehicle and stationary source controls without special land use controls.

Two additional test alternatives were suggested in other AQMP papers[6]:

> Combination Alternative - combining the aspects of previously considered alternatives based on evaluation of their good or bad air quality consequences.

> No Growth Alternative - an "academic" alternative assuming no land development change at all. Designed to examine the effectiveness of other non-land use controls in the absence of additional land use related pollution sources.

The Air Quality "Best Case" Land Development Alternative

One best case land development alternative was structured in detail by ABAG staff with the assistance of the Projections Technical Advisory Committee. This alternative combines the regionwide low population growth assumptions of Base Case 2 with new assumptions about the timing, quantity, location, density, and type of land development that would yield a more compact development pattern. The development assumptions differed from current local policy as follows[7]:

Timing - approximately 30 local jurisdictions which experienced a very rapid growth rate (greater than 5% per year) in the Base Case 2 projections from 1975 to 1980 would be assumed to implement growth managment programs by 1985 to hold the rate to a maximum of 5%.

Quantity - assume State imposed "E-O: sewer capacity constraints 1975 to 1985.

Location - assume development will be encouraged in all areas with existing or committed urban services including "in-fill" areas and "recycling". Assumes development will be discouraged in all areas lacking service commitment as well as areas of environmental concern and regulation. Also assumes relative increase in basic employment in Santa Rosa and Vallejo/Napa SMSAs in the northbay, to balance housing/job growth in these areas.

Density - assumes local policy on zoning density 1975-1980; then increasing densities after 1985 with highest densities in rail transit corridors.

Type - assumes improved job/housing balance in all jurisdictions.

Complete projectional population, housing, employment and land use were developed for this alternative. Detailed assumptions and projection results were reviewed with the Projections Technical Advisory Committee.[8] Based on staff analysis and PTAC recommendations the following major modifications were made in assumptions before re-running the compact development projections for subsequent air quality analysis:

Timing - Assumption of local growth rate limits dropped as inconsistent with objectives of compact development.

Quantity - Assumption of State imposed "E-O" limits on sewerage capacity dropped as test projection results 1975-1985 were already lower than E-O in almost all cases.

Location - Recycling of older housing assumed for more locations based on local planners recommendation. Approximately 50,000 acres of land under environmental or safety regulation assumed not developable until after year 2000. The assumed shift of basic employment growth toward the northbay counties of Sonoma/Napa/Solano was decreased by about 21% based on PTAC review and comment.

Density - Additional low density land assumed deferred from development based on local recommendation. Density assumptions increased in a few jurisdictions.

Type - Same housing/job balance assumed in all jurisdictions. Larger share of basic employment growth assumed in transit corridors.

OBJECTIVES, POLICIES, AND PLANNING ASSUMPTIONS
COMPACT LAND DEVELOPMENT ALTERNATIVE FOR AQMP

This section briefly describes the Compact Development Alternative as it was finally documented for purposes of land use projections and subsequent air quality analysis. The description ties the final assumptions about location, density and type of development to regionwide development objectives.

The Compact Land Development Alternative is premised upon two fundamental objectives which in turn would reduce air pollution:

- Reduce Long Distance Auto Commuting - In the Base Case Projections the continuing South Bay growth trend rapidly consumes all land in the south that is proposed by local agencies for development and urban services. New housing opportunities, which are still premised upon south bay employment opportunities, are gradually shifted further north. The result is more and more excessively long commute trips.

- Reduce the number of auto trips and increase transit usage--encourage higher densities and mixed land uses to bring activities closer together.

The following policies and planning assumptions are the essence of these two objectives in the Compact Land Development Alternative:

Objective:

<u>To Reduce Long Distance Auto Commuting</u>

- Restrict extension of new development to those locations with existing or committed sewer and water services.

  Regionwide about 96 thousand acres of vacant land already has full sewer/water service (this approximates in total area the presently developed area of Alameda County). An additional 71 thousand acres has full service capacity committed in Capital Improvement Programs (this approximates in total area the presently developed area of Contra Costa County). Thus an area of 167 thousand acres, roughly equivalent to the entire developed East Bay area, but distributed regionwide in 83 jurisdictions is fully capable of development within the approximately 20 year planning period. At zoning densities higher than currently allowed in most jurisdictions, but not higher than the typical density in existing urban areas, this developable land supply could accommodate nearly 600 thousand dwelling units, or approximately the high projection of regionwide housing need to 1990.

Totally restricted from development would be 97 thousand acres (roughly equivalent to the already developed area of Santa Clara County, or approaching in magnitude the amount of non-developable land currently in public use in Marin County (Pt. Reyes, GGNRS, Marin Municipal Water District, etc.).

- -- 19 thousand acres, outside city spheres and lacking either sewer or water service commitments. This land, is located in 8 counties.

- -- 50 thousand acres, outside city spheres of influence, in 8 counties and regulated for flood, slope, or soil problems.

- -- 28 thousand acres, outside city spheres of influence in 4 counties and currently covered by agricultural zoning or other "holding zone" regulation.

- Encourage "infill" development of bypassed vacant land and encourage public and private rebuilding.

Given the above proposed restrictions on development "sprawl" it will also be essential to accommodate a major share of development within the already developed areas.

- -- It is estimated that at least 4 to 10 thousand acres of developable land--small bypassed vacant lots--is scattered throughout the region. It is anticipated that much of this land has unique site problems, service problems, or ownership/financing problems that will make it difficult to bring into the developable land supply.

-- A major rebuilding effort would be needed involving as much as 12 thousand acres in 33 jurisdictions (roughly equivalent in magnitude to the entire older developed area of west Berkeley and northwest Oakland). Publicly assisted redevelopment programs now in various stages in San Francisco, Oakland, Berkeley, Richmond, San Jose, etc. are small relative to this need. Current private rebuilding efforts are so small and scattered that their magnitude is unknown.

Such infilling of new development and rebuilding programs could enable exisitng urban areas in the region with existing or committed services to accommodate almost 250 thousand housing units in closer proximity to job opportunities, thus reducing auto travel.

- Encourage urban development in north bay jurisdictions where urban service capacity exists or can be committed, while restricting development in south bay jurisdictions consistent with existing or committed urban service capacities.

The north bay jurisdictions are already encouraging urbanization by virtue of the developable land zoned for industrial and residential uses with sewer and water service commitments.

DISTRIBUTION OF
REGIONAL URBAN LAND RESERVES

County	Share of Regionwide Industrial Land Reserve	Share of Regionwide Housing Reserve: Acres	Share of Regionwide Housing Reserve: Capacity for Housing
Sonoma	5%	23%	15%
Napa	6	2	2
Solano	30	12	11
NORTH BAY	41%	37%	28%
Contra Costa	12%	24%	17%
Marin	3	5	3
EAST/WEST BAY	15%	29%	20%
San Francisco	1%	-	2%
Alameda	18%	9%	14%
San Mateo	5	15	5
Santa Clara	20	9	31
SOUTH BAY	53%	33%	50%
REGION	100%	100%	100%

Under a continued south bay growth trend, as indicated in Base Case 2, south bay jurisdictions' supply of developable residential land would likely be consumed by 1990 while in the northbay about 28 thousand acres would remain unutilized, 17% of the regionwide reserve of such land. The major locations of such an untapped development reserve is the Santa Rosa area of Sonoma county and the Vallejo, Vacaville, and Dixon areas in Solano County.

Despite extensive industrial land reserves in the northbay, the attraction of existing industrial concentrations in the south bay indicates that area continuing to attract a share of new industrial jobs for beyond its proportion of industrially reserved land. This is especially true in Santa Clara County where about 1/4 of the region's industrial base is expected to attract almost 1/2 of the region's new industrial jobs between now and 1990.

The AQMP Compact Development Alternative assumes a gradual shift in this trend with the north bay counties capturing about 21% of new basic jobs, while Santa Clara still captures about 41%. San Francisco and other east and west bay locations would capture about the same share of total job growth (about 30%). This slight northward shift in economic growth would be more consistent with the regionwide aggregate of local jurisdictions' development policy in terms of industrial development and could be expected to be balanced by residential development attracted to job opportunities.

The air quality alternative would accommodate 22% of the regions new residential growth in the 3 north bay counties with Sonoma County's 14% doubling its share of growth from the trends of Base Case 2. The resulting more balanced housing/jobs development pattern would be well within northbay jurisdictions indicated capacity to provide services, and enable less long distance commuting from the north bay to job opportunities in San Francisco and the East Bay. Even with the limited northward emphasis on development it is estimated that only about 54% of the northbay counties currently serviceable land would be built-out by the year 1990.

Some of the northward shift would be as close as from Santa Clara County to Alameda and San Mateo counties. This would reduce the need for long distance commuting from residential development in these counties to job opportunities in Santa Clara.

How to accomplish this shift in economic development is the question, and perhaps at issue. It is already happening to a minor degree (e.g., Hewlett-Packard's move to Santa Rosa). But a much more pronounced shift will be needed (from 12% to 21% of total region basic job growth in the north bay) to reach the balanced development-lower commuting levels of the Air Quality Alternative. In addition to the service policies proposed state action to establish new incentives for economic development in the north bay may be needed, as well as commitments to transportation facilities.

Objective:

<u>To Reduce Auto Trips and Increase Transit Usage</u>

- o Encourage higher density development where existing or committed service capacities, including rail transit, can support higher densities.

The Compact Development Alternative is premised upon increasingly higher density development in rail transit corridors, consistent with sewer and water system capacities, to both support transit usage and discourage auto dependency:

-- 45 thousand acres of developable land in 15 jurisdictions in the BART system corridors and 19 jurisdictions in the Southern Pacific rail system corridor is assumed to develop at densities which will reach two to three times the currently zoned density by the year 2000.

-- 29 thousand acres in the Golden Gate express bus system area and 18 thousand acres in the AC Transit express bus system area is also assumed to develop at densities 50% to 100% greater by the year 2000 than current zoning permits.

This densification would enable the existing urban areas regionwide to accommodate almost 520 thousand more dwelling units than current zoning densities would allow.

- o Discourage development of land within urban service areas where soil, slope, or other conditions can support only low density development.

The Compact Development Alternative advocates delaying development of 32 thousand acres, generally inside city spheres of influence but regulated for development problems such as flood, slope, or soil (septic) characteristics. This land, scattered through 25 city and 5 county jurisdictions, is asssumed developable after 1990 at densities as currently regulated.

- o Expedite completion of needed sewer and water service improvements in all suitable locations within or contiguous to existing urban areas.

In order to make the above described restrictions on development workable while still accommodating the full amount of development needed for the region, it will be necessary to assure the availability of sewer and water service when and where needed on a regionwide basis:

-- For the 71 thousand acres cited above where full service does not yet exist but is committed in Capital Improvement Programs. Construction of those facilities to serve an area roughly equivalent

to the already developed area of Contra Costa County by 1985 will be a major undertaking of obvious regional scope and commitment.

-- For the 12 thousand acres in 38 jurisdictions cited above where either sewer or water service is not yet committed, facility plans and funding programs must be expedited. Individually some of these smaller areas of limited development potential might seem insignificant, but in aggregate and in the context of development restrictions described above they become critical to the regionwide need for development.

- Delay auto dependent land development which could preclude transit improvements.

The Compact Development Alternative assumes other jurisdictions will do as Santa Clara did in early 1977 enacting a temporary moratorium on low density "lot-split" suburban development for the period while land use/ transit studies examine transit potential for the areas in question. Low density development now could close out feasible transit options.

- Encourage a mixture of residential/commercial/industrial development types in all jurisdictions, while discouraging large scale exclusively single-use developments.

Reduction of auto usage will require all jurisdictions to discourage the development of new "bedroom suburbs" where jobs, shopping, and recreation opportunities are not accessible except by auto. Likewise the development of "industrial cities" without balanced growth in housing ordains long distance commuting as well as interjurisdictional service inequities.

Objective:

<u>Increase The Efficiency of Transportation Systems to Avoid Congestion</u>

Transportation decisions must be tightly tied to land development actions to avoid the congestion that occurs when land development occurs before the transportation facilities to support it are built.

- Integrate the timing of highway and transit improvements with local policy on when development should occur.

The design of transportation facilities should recognize their growth inducing effects. For example, a rural area freeway can be designed and built with provision for <u>later</u> interchanges in keeping with the local jurisdictions plans for land development and other service improvements.

- o Program funding of needed highway and transit improvements consistent with development sequence zoning.

If local jurisdictions adopt development sequence zoning to control the timing of development, the capital improvement programs of transportation agencies (e.g., CalTrans, BART) should specifically recognize such timing assumptions in their own assumptions about when funding will be available and when will it be spent for facility improvements.

ADDRESSING THE REGIONAL/LOCAL ISSUE

Analysis to date indicates that, assuming the lowest likely rate of regional growth (Base Case 2) in conjunction with a compact higher density regionwide development pattern such as described above, land use controls implemented by local jurisdictions can have significant effect in improving air quality in the long range future 1985-2000. Though not analyzed to this degree, the highest likely regional growth rate (Base Case 1) would probably require state and/or regional intervention in land development to a greater degree and more widespread than the localized building permit moratoria, sewer hook-up moratoria, and sewer facility funding limitations imposed by state and regional agencies in recent years.

The analysis of the Compact Development projections indicates that:

- o Vehicle miles of travel could be expected to decline from the Base Case 2 (year 2000) level of 90 million vehicle miles to 80 million, a reduction of about 12%. This margin of improvement over the non-compact but low growth assumptions of Base Case 2 is about as much as that low growth scenario would itself improve the situation as against the high growth assumptions of Base Case 1.

- o Transit use could be expected to increase significantly over the estimates for Base Case 2 as a result of higher levels of development within transit service areas. While jobs locating in transit service areas are assumed to remain the same in the Compact Development Alternative (approximately 3/4 of total new jobs) the share of new housing units and employed residents locating near transit is assumed to increase. Approximately 89 thousand more housing units (15% of regionwide growth by 1990) and 36 thousand more employed residents (10% of growth) would be near transit and have the option of transit for either long or short commute trips. As a result of both the Compact Development Development assumptions and assuming improved transit service levels about 1.6% of total work trips regionwide could be expected to switch from auto to transit.

As a result of a better balance of housing and jobs within most major subregional areas long distance commuting would decline significantly under the Compact Development Alternative. The San Francisco, Oakland, Berkeley and San Jose/Palo Alto employment centers would see a reduction of in-commuting (10 to 20 thousand fewer in-commuters each).

Among the suburban locations which would experience reduction of about 5000 or more out-commuters would be Marin County, the Vacaville area, the San Pablo/Pinole area, the Livermore/Amador Valley, and the areas east and south of San Jose.

As a result of the changes in development patterns and consequent total vehicle emissions could be expected to be reduced from the level of Base Case 2 approximately as follows:

Hydrocarbons	11%
Carbon Monoxide	10%
Oxidant Nitrogen	10%

Even with these possible improvements in travel and pollutant emissions, the major question remains:

> CAN THE POLICIES AND ACTIONS AS STATED HEREIN, AND LARGELY LEFT TO LOCAL AGENCIES (primarily cities, counties, and Local Agency Formation Commissions) TO IMPLEMENT, ACCOMPLISH THE NEEDED CHANGE IN LAND DEVELOPMENT PATTERNS?

We believe the answer is a qualified YES. Most of the actions indicated in the appendix are already underway in some jurisdictions in the Bay Region--but not for air quality objectives. They are often put into effect to accomplish more localized objectives such as balancing the fiscal books by either encouraging commercial/industrial development or discouraging residential development. Even more widespread are land use controls such as planned unit developments geared to aesthetic or safety objectives. The LAFCO mandate to make sense out of urban service provision as it relates to land development and annexation is paramount.

It will take much time and effort to see that such controls are carried out with regionwide consistency. Such regionwide consistency is not anticipated in the short term future. None should be expected to be effectively operational for 5 to 10 years. Real effectiveness in air quality terms should not be expected for at least 15 years.

Other benefits may also accrue:

- Greater efficiency and economy in provision of essential urban services;
- Energy savings are likely, at least in terms of fuel;
- Some objectives of the regional open space plan may be realized;
- Transit ridership sufficient to make more extensive and frequent transit service feasible in more parts of the region may obtain.

Accomplishing some of the air quality objectives will be more difficult than others. The mechanics to control development at the suburban fringe already exist and have had extended experience in some jurisdictions. The "urban service area" concept of the Santa Clara County (and cities) Urban Development/Open Space Plan stands as a well tested model for application in other parts of the region.

Encouraging new development and rebuilding inside the already urbanized areas will require public and private commitments of a scale that may seem naive in light of the redevelopment experiences of the last two decades.

The proposal to increase densities over such a widespread area will inevitably raise much controversy. Many jurisdictions have been doing just the reverse: "downzoning" neighborhoods in the interest of preserving neighborhood character and to prevent undue impact on certain limited service capacities. The methods do exist to accomplish higher density without destroying neighborhood character.

The concept of moving toward a balance of regional growth in the northbay and southbay will likely polarize special interest groups with objectives other than air quality. It will raise the spector of unwanted growth for some and the loss of anticipated growth for others.

Expediting sewer and water improvements in some areas in the interest of accommodating a regional need for certain types of development will raise the issue of who pays for improvements that have major localized benefit but also significantly contribute to a regionwide need for development in the right place at the right time.

Encouraging mixed land uses runs counter to "recent tradition" in land development and will raise questions of amenity and effect on present property values. The Bay Region has perhaps a stronger tradition for such diversity than other developing regions.

None of the policies and actions are especially exotic. As indicated above they are relatively "tried and true" in scattered applications for other objectives. Carrying them out at the scale indicated for Bay Region air quality will be an unprecedented challenge for both the public and private sector.

FOOTNOTES

1 The specific measured effects of likely improvement to air quality is discussed in another paper. See Effectiveness and Costs of Alternative Air Pollution Control Programs, AQMP Tech Memo #14, ABAG, September 1977.

2 The legal authority and potential funding mechanisms for these agencies to undertake the actions proposed are documented in another paper. See Institutional, Legal and Financial Requirements for Implementing Proposed Air Pollution Control Programs, AQMP Tech Memo #16, ABAG, September 1977.

3 See AQMP Tech Memo #4, Status of Existing Controls Related to Air Pollution, March 1977. Also see AQMP Brief No. 2, Alternative Air Quality Strategies, for EMTF, June 1977. For more detailed description of the Local Development Policy Survey see Provisional Series 3 Projections, ABAG, March 1977.

4 For detailed discussion see A Concept For Land Development Policy Alternatives in the Regional Plan, ABAG discussion paper for the Projections Technical Advisory Committee, May 1977. For summary see AQMP Technical Memo 5, Candidate Control Measures, ABAG/MTC/BAAPCD, April 1977.

5 See Development and Analysis of Alternative Air Quality Strategies, AQMP Tech Memo 7, ABAG/MTC/BAAPCD, July 1977.

6 See Candidate Control Measures, AQMP Tech Memo 5, ABAG/MTC/BAAPCD, April 1977.

7 See Draft Planning Assumptions For The "Compact Growth" Projection Alternative For AQMP, Working Paper for Projections Technical Advisory Committee, ABAG, June 23, 1977. Final assumptions are documented in detail in The Compact Growth Projection Alternative for AQMP, Working Paper for Projections Technical Advisory Committee, ABAG, July 19, 1977.

8 Projections Technical Advisory Committee is composed of planners from Bay Region cities and counties as well as technical staff from state and regional agencies.

APPENDIX

The following appendix lays out the air quality objectives and associated land development policies along with specific actions which could be implemented by specific agencies to carry out each policy. The actions for each policy constitute a set of actions which, taken together, could have greater success for the policy and objective in question. The more actions taken the more likely the policy can succeed. The more of the policies carried out for each objective the greater the likelihood of achieving the objective--and cleaner air.

OBJECTIVE A-1: REDUCE LONG DISTANCE AUTO COMMUTING (WITHIN SUBREGIONAL AREAS

- REDUCE CURRENT LONG-DISTANCE AUTO COMMUTING AND DISCOURAGE URBAN DEVELOPMENT REGIONWIDE THAT RESULTS IN MORE AUTO COMMUTERS IN MORE URBAN AREAS. INDUCE MORE COMPACT URBAN DEVELOPMENT IN ALL URBANIZING AREAS OF THE REGION THROUGH LAND MANAGEMENT TECHNIQUES. USE URBAN SERVICE COMMITMENTS AS INCENTIVES FOR COMPACT DEVELOPMENT AND DISINCENTIVES FOR SCATTERED DEVELOPMENT.

		RESPONSIBLE AGENCIES
Policy 1:	Restrict the extension of new development to those locations with existing or committed sewer and water service.	
Action	a) Complete LAFCOs' regionwide adoption of city and service district spheres of influence.	LAFCOs.
Action	b) Adopt "Urban Service Area" concept for defining city and service spheres of influence in terms of service commitments and projected land needs. (5 year, 10 year, 20 year estimates).	LAFCOs.
Action	c) Carry out policy on formation and annexation of cities and service districts consistent with (b) above.	Cities, Special Districts, LAFCOs.
Action	d) Enact non-urban zoning (Agricultural zoning "Holding Zones") outside urban service areas.	Cities, Counties.
Action	e) Enact temporary moratoria on rezoning and subdivision outside of urban service areas.	Cities, Counties.
Policy 2:	Restrict development of locations outside urban service areas which constitute critical areas of environmental concern (environmental resources, hazards, or amenities).	
Action	a) Establish programs of public land acquisition purchase/transfer of development rights, purchase/leaseback, etc.	Cities, Counties, Special Districts, BCDC, Cal. Coastal Conservancy.
Action	b) Continue or expand programs under Calif. Land Conservation Act (Williamson Act), Open Space Easement Act, Forest Taxation Reform Act.	Cities, Counties.
Action	c) Enact or expand agricultural zoning and large lot rural residential zoning (generally one dwelling unit/40 acre minimum lot size) where appropriate, to restrict development of critical environmental areas.	Cities, Counties.

OBJECTIVE A-1, Continued

		RESPONSIBLE AGENCIES
Policy 3:	Encourage development of unimproved land within or next to urban areas with existing or committed urban services. Emphasize sewer and water service capacities.	
Action	a) Establish "early warning" inter-agency information exchange and project reviews of sewer/water projects via A-95 review and clean water grant plan EIR review.	ABAG, Cities, Counties, LAFCOs.
Action	b) Expedite city, county, LAFCO or ABAG project reviews where needed information on service capacities has been provided via (a) above.	Cities, Counties, Special Districts, LAFCO, ABAG.
Action	c) Initiate rezoning and permit preference procedures in locations with excess capacity in sewer/water/transportation service.	Cities, Counties, Special Districts.
Policy 4:	Expedite completion of needed sewer or water service improvements in all suitable locations within or next to existing urban areas.	
Action	a) Expand and expedite general purpose agency reviews of single purpose service agencies' Capital Improvement Programs to coordinate service schedules.	ABAG, MTC, Counties, Cities, LAFCOs, Special Districts.
Action	b) Use A-95 review and funding allocation procedures to expedite State/Federal financial assistance to agencies lacking service capacity in areas where other services already are capable of accommodating additional development.	ABAG, MTC.
Policy 5:	Encourage "infill" development of bypassed vacant land within existing urbanized areas.	
Action	a) Undertake planning studies to inventory bypassed land; identify development problems, and resolve questions of best potenital use.	Cities, Counties, ABAG, Cal OPR.
Action	b) Make necessary changes in zoning and permit procedures to facilitate the development of bypassed parcels affected by special conditions. Review procedures for zoning variances and applicability of planned unit developments and/or floating zones.	Cities, Counties.
Action	c) Design sewer/water/transportation systems to improve access to and service to bypassed vacant land.	Cities, Counties, Special Districts.
Action	d) Permit the transfer of development rights from undeveloped fringe areas to vacant land within existing urbanized areas.	Cities, Counties.
Policy 6:	Increase housing and job opportunities in existing urbanized areas. Encourage public and private rebuilding into compatibly mixed land uses at higher densities.	
Action	a) Initiate and/or expand housing conservation programs and housing replacement programs in the already urbanized areas.	Cities, Counties, ABAG.

OBJECTIVE A-1, Policy 6, Continued

		RESPONSIBLE AGENCIES
Action	b) Initiate and/or expand private and publicly assisted industrial development and redevelopment programs in the already urbanized areas.	Cities, Counties, Redevelopment Agencies.
Action	c) Initiate and/or expand capital improvement and maintenance programs, and community facilities and services which can serve as direct incentives to redevelopment in the urbanized areas. Emphasize sewer and water facilities and intensive transit service improvements. Also include educational and cultural facilities and public safety services.	Cities, Counties, Special Districts.

OBJECTIVE A-2: REDUCE LONG DISTANCE AUTO COMMUTING (BETWEEN SUBREGIONAL AREAS)

- SLOW THE TREND TOWARD INCREASED LONGER-DISTANCE AUTO COMMUTING TO SOUTH BAY LOCATIONS RESULTING FROM:

  -- A continuing imbalance between wouth bay regional growth trends and underutilized service capacities in the north bay.

  -- A continuing pattern of unbalanced job/housing growth in the south bay.

  INDUCE A LARGER SHARE OF NEW REGIONAL JOB AND HOUSING DEVELOPMENT INTO NORTH BAY LOCATIONS AND ESTABLISH MATCHING DISINCENTIVES TO DEVELOPMENT IN THE SOUTH BAY.

Policy 7:	Encourage urban development in north bay jurisdictions where urban service capacity exists or can be committed by joint local/regional/state action.	
Action	a) Conduct A-95 plan and project reviews to encourage development in appropriate north bay jurisdictions.	ABAG, MTC.
Action	b) Support state/federal funding allocations for services and facilities which would offer incentives to development in these jurisdictions.	ABAG, MTC, Cal OPR, Cities, Counties.
Policy 8:	Restrict the intensification of development in south bay jurisdictions to a population level or employment level consistent with existing or committed urban service capacities. Emphasis would be on sewer and water capacities but also include other urban services such as schools, fire protection, police protection, etc.	
Action	a) Enact temporary moratoria on rezoning and subdivisions.	Cities, Counties.
Action	b) Enact temporary moratoria on building permit and sewer/water hook-ups.	Cities, Counties, Special Districts.
Action	c) Limit state/federal funding of south bay urban service improvements to current design and funding levels.	ABAG, MTC, Cal OPR, SWRCB, RWQCB.

- REVERSE THE TREND OF MORE AUTO TRIPS AND LESS TRANSIT USAGE. USE LAND MANAGEMENT TECHNIQUES AND SERVICE COMMITMENTS AS INCENTIVES FOR HIGHER DENSITY DEVELOPMENT. IN ALL NEW LAND DEVELOPMENT REGIONWIDE:

  -- Promote high density development that is supportive of transit usage.

  -- Discourage low density development that promotes automobile dependency.

			RESPONSIBLE AGENCIES
Policy 9:		Encourage higher density development in urban areas where existing or committed urban service capacities, including rail transit, can support higher densities.	
Action	a)	Increase density and multiple uses in vicinity of high capacity rail transit service by changes in zoning.	Cities, Counties.
Action	b)	In urban areas with adequate sewer and water capacities, rezone appropriate locations to permit higher densities.	Cities, Counties.
Action	c)	Review general plans and development projects in urban areas in keeping with criteria on service capacities.	ABAG, MTC, LAFCOs, Cities, Counties.
Action	d)	Enact Planned Unit Development ordinances with density bonus systems consistent with urban service capacities.	Cities, Counties.
Policy 10:		Discourage development of land within urban service areas where soil, slope, or other physical conditions can support only low-density development.	
Action	a)	Establish programs of public land acquisition purchase/transfer of development rights, purchase/leaseback, etc.	Cities, Counties, Special Districts, BCDC, Coastal Conservancy.
Action	b)	Enact Planned Unit Development (PUD) and/or "Cluster Zoning" Ordinances to enable higher densities on appropriate sites.	Cities, Counties.
Action	c)	Deny essential urban services to these low-density locations through exclusion from capital improvement programs, exclusion in system design, enactment of hook-up moratoria, etc.	Cities, Counties.
Action	d)	Deny annexation of these low-density locations to service providing jurisdictions.	LAFCOs.
Policy 11:		Defer for short periods of time (2 years or less) auto-dependent land development which would preclude pending transit improvements.	
Action	a)	Enact temporary moratoria on rezoning and subdivisions.	Cities, Counties.

OBJECTIVE B, Policy 11, Continued

- REVERSE THE TREND OF MORE AUTO USAGE. USE LAND MANAGEMENT TECHNIQUES TO ACHIEVE A BETTER BALANCE OF HOUSING, COMMERCE, AND INDUSTRY IN EACH URBAN AREA.

		RESPONSIBLE AGENCIES
Policy 12:	Encourage a mixture of residential/commercial/industrial development types in all communities.	
Action	a) Revise zoning ordinances to allow mixtures of land uses with adequate design or performance standards.	Cities, Counties.
Action	b) Expand application of "Planned Unit Development Zones" or "Floating Zones."	Cities, Counties.
Action	c) Expand use of Conditional Use Permits.	Cities, Counties.
Policy 13:	Discourage new large-scale land development projects that are exclusively commercial, industrial or residential.	
Action	a) Deny incorporation of, or continued annexation of "single-use" large-scale land development projects.	LAFCOs.
Action	b) Deny regional transportation system access or extension to "single-use" large-scale development projects.	MTC.

OBJECTIVE C: INCREASE THE EFFICIENCY OF TRANSPORTATION SYSTEMS TO AVOID CONGESTION.

- PREVENT THE ADDED POLLUTION CAUSED BY SHORT-TERM INEFFICIENCIES OF HIGHWAYS AND TRANSIT SYSTEMS SERVICE TO NEW LAND DEVELOPMENT. STAGE LAND DEVELOPMENT PLANS WITH THE FUNDING SCHEDULES OF NEEDED HIGHWAY/TRANSIT IMPROVEMENTS TO:

  -- Minimize congestion on highways and transit systems caused by premature land development;

  -- Allocate the limited resources for highway transit improvments to the place and time they can best contribute to minimize air pollution.

Policy 14:	Integrate the timing of highway and transit system improvements with local policies on sequence of land development.	
Action	a) Enact Development Sequence Zoning (aka "Timing Zoning, "Phrased Zoning").	ABAG, Cities.

OBJECTIVE C, Policy 14, Continued

		RESPONSIBLE AGENCIES
Action	b) Recognize staged land development plans in planning and programming of highway and transit improvements.	ABAG, MTC, Cities, Counties, CalTrans.
Policy 15:	Program funding of needed highway and transit improvements consistent with development sequence zoning.	
Action	a) Adopt Highway Capital Improvement Programs consistent with city/county approvals of sequence zoning.	Cities, Counties, MTC, CalTrans.
Action	b) Adopt Transit Capital Improvement Programs and operating budgets consistent with city/county approvals of land development projects and sequence zoning.	Cities, Counties, Transit Service Districts, MTC.
Action	c) Enact Performance Standard Zoning with criteria for assessment of land development projects impact on highways and transit service.	Cities, Counties.

ENVIRONMENTAL MANAGEMENT PROGRAM

AIR QUALITY MAINTENANCE PLAN BRIEF NO. 1

THE GOAL. FUTURE DECISIONS, ISSUES AND ORGANIZATION

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RONALD Y. WADA

PREPARED FOR THE

ENVIRONMENTAL MANAGEMENT TASK FORCE

MARCH, 1977

CONTENTS

INTRODUCTION

This is the first of four briefs on the Air Quality Maintenance Plan (AQMP). It covers the goal, key issues, and program organization. All briefs will report on work progress and schedule, problems, advisory committee comments, and an updated view of the final product. Subsequent briefs will describe:

- The air quality problems (extent, severity, and emission sources)
- Alternative controls for solving the problem
- The preliminary regional AQMP

The goal of the Environmental Management Program is to produce seven management plans (including the AQMP) with the following characteristics:

- They will lead to the greatest possible improvement in air and water quality and problems caused by solid waste, and will lead to compliance with federal and State standards and objectives at the earliest possible date.
- They will not have social, economic, or environmental effects so unacceptable as to prevent implementation.

For the AQMP, the goal may be more specifically stated as follows:

- The goal of the AQMP is attainment and maintenance of State and federal air quality standards as expeditiously as practicable.

As background information, the predecessor to the Environmental Management Task Force (EMTF) was the Air Quality Maintenance Plan-Policy Task Force. This group, established in the summer of 1975, was composed of thirty-four elected officials and individuals representing public and special interests. During its tenure, the Air Quality Maintenance Plan-Policy Task Force adopted two resolutions (see Appendix A). The first resolution affirmed the region as an appropriate air quality maintenance area. It recognized existing and projected air

quality problems and supported a locally based air quality maintenance planning process. Resolution two transferred the responsibilities of the Policy Task Force to the EMTF, thereby creating a policy body to oversee development of an integrated environmental management planning program.

Development of the AQMP has been underway for approximately eight months. The goal of the plan has been formulated and key future decisions have been identified. Steady progress has been made and some program problems are developing. It is uncertain at this time what the AQMP approval process will consist of. Other uncertainties in the program exist because of pending legislation to amend the Clean Air Act of 1970 and the unique AQMP planning process which has been developed. For this first major review of the AQMP, four issues are raised for EMTF actions.

Issue: Air quality standards are being violated in the Bay Area. The Clean Air Act of 1970 requires meeting these standards this year. The prospects of doing so are very unlikely. Proposed legislation to revise the Clean Air Act of 1970 would allow for more time to meet the standards. Therefore, the goal of the AQMP is attainment and maintenance of federal and State air quality standards as expeditiously as practicable.

EMTF Action: Adopt the goal of the AQMP as stated.

Issue: Two sets of air quality standards exist in California. Federal standards were set by the U.S. Environmental Protection Agency. A similar set has been adopted by the California Air Resources Board. Both sets of air quality standards are based on human health effects of sensitive population groups. In general, it is assumed that the more stringent standards apply. Such an assumption is conservative with respect to protecting human health. Given the significant differences in several of the standards, it may also mean considerable additional cost to achieve all of the most stringent standards as expeditiously as practicable.

EMTF Action: Request clarification from the California Air Resources Board on the requirement for attainment of California air quality standards vis-a-vis federal standards. In particular, a statement of the California Air Resources Board policy regarding time schedules for attainment of standards should be sought.

Issue: A wide variety of agencies have responsibility for air pollution control programs. Future control strategies are likely to require federal, State, regional, and local government participation and implementation. An important future decision will be determining the appropriate level of federal, State, regional, and local responsibility for additional air pollution controls consistent with the AQMP goal. Unclear is how this level of responsibility for controls will be determined and what plan approval process will be used for the AQMP adoption.

EMTF Action: Seek clarification from the California Air Resources Board and Environmental Protection Agency regarding the plan approval process as it pertains to the AQMP.

Issue: A number of program management issues have developed, the most serious of which is the possibility of substantial delays to completion of the AQMP on schedule. Some difficulties have been encountered in organizing and efficiently managing the Joint Technical Staff. Overall, the program manager exercises limited control over budgets and staff working on the program.

EMTF Action: Two options are available for discussion and possible action: 1) Reschedule the AQMP based on the latest information available concerning probable completion dates of AQMP tasks. A rough estimate of the implications of such a decision is that the AQMP will be 6-12 months late. This option maintains the status quo. 2) Affirm the desire to maintain the AQMP as part of the Environmental Management Plan, including delivery of the AQMP on the original schedule. This option would require substantial changes to the present mode of operation.

THE GOAL

The goal of the AQMP is attainment and maintenance of State and federal air quality standards as expeditiously as practicable. Air quality standards are currently being violated and are projected to be violated in the future. The Clean Air Act of 1970 requires meeting these standards no later than 1977. The goal of the AQMP, therefore, recognizes the practical realities of being unable to satisfy this requirement. The AQMP program establishes a process for developing a plan to meet these standards as soon as practical. Such an approach is consistent with current versions of Clean Air Act Amendments under consideration by Congress. The proposed legislation allows flexibility in attainment schedules on a case-by-case basis where it is clearly demonstrated that additional time beyond 1977 will be required.

In a sense the AQMP (Air Quality Maintenance Plan) is a misnomer since many of the air quality standards have yet to be achieved. Attainment requires meeting the standards where violated, e.g. photochemical oxidant. Maintenance requires maintaining standards once they have been met. For example, the SO_2 standards may be difficult to maintain if fuel oil is used extensively instead of natural gas.

Both the California Air Resources Board and the Environmental Protection Agency have adopted ambient air quality standards to protect public health. Differences exist between the federal and State standards. In general, it has been assumed by the California Air Resources Board that the more stringent standards apply. Such an assumption is conservative with respect to protecting public health. It may also mean considerable additional cost to achieve the most stringent standard in all cases. Table 1 presents California and federal air quality standards.

Recent drafts of proposed Clean Air Act Amendments allow a 5 year extension (to 1982 for the Bay Area) where it can be shown to be necessary. Additional five year extensions beyond 1982 can be obtained assuming 1) demonstrated need and 2) "good faith" efforts, and steady progress toward attainment. Flexibility is permitted for obtaining extensions where it is documented they are warranted. However, EPA has repeatedly stressed that additional time

TABLE 1
AMBIENT AIR QUALITY STANDARDS

POLLUTANTS	AVERAGING TIME	CALIFORNIA STANDARDS	NATIONAL[1] STANDARDS
PHOTOCHEMICAL OXIDANTS	1 HR.	0.10 ppm	0.08 ppm
CARBON MONOXIDE	12 HR.	10 ppm	
	8 HR		9 ppm
	1 HR.	40 ppm	35 ppm
NITROGEN DIOXIDE	ANNUAL AVERAGE		0.05 ppm
	1 HR.	0.25 ppm	
SULFUR DIOXIDE	ANNUAL AVERAGE		0.03 ppm
	24 HR.	0.10 ppm	0.14 ppm
	1 HR.	0.5 ppm	
SUSPENDED PARTICULATE MATTER	ANNUAL GEOMETRIC MEAN	60 $\mu g/m^3$	75 $\mu g/m^3$
	24 HR.	100 $\mu g/m^3$	260 $\mu g/m^3$
LEAD	30 DAY AVERAGE	1.5 $\mu g/m^3$	
HYDROGEN SULFIDE	1 HR.	0.03 ppm	
HYDROCARBONS (CORRECTED FOR METHANE)	3 HR. (6-9 a.m.)		160 $\mu g/m^3$
ETHYLENE	8 HR.	0.1 ppm	
	1 HR.	0.5 ppm	
VISIBILITY REDUCING PARTICLES	1 OBSERVATION	IN SUFFICIENT AMOUNT TO REDUCE THE PREVAILING VISIBILITY TO LESS THAN 10 MILES WHEN THE RELATIVE HUMIDITY IS LESS THAN 70%	

NATIONAL STANDARDS, OTHER THAN THOSE BASED ON ANNUAL AVERAGES OR ANNUAL GEOMETRIC MEANS, ARE NOT TO BE EXCEEDED MORE THAN ONCE PER YEAR.

[1] NATIONAL PRIMARY STANDARDS: THE LEVELS OF AIR QUALITY NECESSARY, WITH AN ADEQUATE MARGIN OF SAFETY, TO PROTECT THE PUBLIC HEALTH. EACH STATE MUST ATTAIN THE PRIMARY STANDARDS NO LATER THAN THREE YEARS AFTER THAT STATE'S IMPLEMENTATION PLAN IS APPROVED BY THE ENVIRONMENTAL PROTECTION AGENCY (EPA).

extensions will be granted only where steady progress is evidenced through implementation of additional control programs. In recently submitted drafts of amendments to the Clean Air Act of 1970, Congress has specified requirements for programs they expect to be implemented prior to granting additional time extensions, e.g. inspection and maintenance.

EMTF Action:

1) Adopt the goal of the AQMP as stated.

   "The goal of the AQMP is attainment and maintenance of federal and State air quality standards as expeditiously as practicable."

2) Request clarification from the California Air Resources Board on the requirement for attainment of California air quality standards vis-a-vis federal standards. In particular, a statement of the California Air Resources Board policy regarding time schedules for attainment of standards should be sought.

FUTURE DECISIONS

Given the goal of the AQMP as previously stated, several key future decisions are identified:

- Defining "as expeditiously as practicable"
- Determining the appropriate level of federal, State and local responsibility for additional air pollution controls consistent with the goal.

Both issues require balancing of environmental objectives and standards with social and economic costs of achieving the objectives. Also, since State and federal agencies are likely to be responsible for implementing parts of the AQMP, it is very likely the key issues raised will require extensive State (and possibly federal) negotiations.

Defining "as expeditiously as practicable"

Many parts of the country, including the Bay Area, are experiencing difficulty in meeting the requirements of the Clean Air Act of 1970. This Act mandates that air quality standards be achieved, and thereafter maintained, by no later than 1977. It does not allow for consideration of social and economic impacts in developing strategies to meet the standards. The rigid timetable and stringent standards have resulted in proposals for many unrealistic programs and programs that have major social and economic impacts.

Recognizing these difficulties, Congress is currently working to amend the 1970 Clean Air Act. During 1976, Congress was unable to pass such amendments to the Act; several amendments have already been introduced during this current session. The proposed legislation allows a five year extension for achieving federal standards. Such an extension is predicated upon the implementation of all reasonable and available measures. Criteria to be used for evaluating requests for extensions will include social or economic impacts of the control strategies on the region. Additional five year extensions are also likely to be permissible based on demonstrated need for the time.

It is assumed that EPA expects the State, through the

California Air Resources Board, will recommend reasonable attainment schedules. It is uncertain how the California Air Resources Board will work out with local governments what reasonable attainment schedules will be recommended. In either event EPA may negotiate these schedules with State and local governments, based on the strategies and implementation schedule proposed for all reasonable and available measures. The plan approval process and how EMTF and the California Air Resources Board are to be involved in negotiating appropriate attainment schedules are yet to be determined. The important issue is what process and procedures will be used by EMTF and the California Air Resources Board to determine mutually acceptable attainment deadlines. This issue is related to the overall plan approval process. The rationale for early State involvement in determining the implementation schedule is that many of the control measures being considered require direct State involvement for implementation, e.g. motor vehicle retrofit, inspection and maintenance.

Determining the appropriate level of federal, State, and local responsibility for additional air pollution controls consistent with the goal.

A number of agencies have direct control over air pollution sources. Many other agencies affect air quality indirectly through policies of their agencies. The AQMP is concerned with both direct and indirect causes of the problem. Therefore, it must deal with both control strategies and policies which influence air quality. The Clean Air Act is explicit in the requirements that comprehensive control programs be developed, stating that

> "a plan implementing.... air quality standard(s)... includes emission limitations, schedules, and timetables for compliance with such limitations, and such other measures as may be necessary to insure attainment and maintenence of... standard(s), including, but not limited to, land use and transportation controls."

To date, many air pollution controls have been implemented. They have been implemented by a variety of agencies, and as a result, significant air quality improvements have been achieved in the Bay Area. However, since considerable progress is still needed, additional control programs will be required. It is generally agreed that the easy solutions have been implemented. Simple or single focus approaches to the Bay Area's air pollution problem are unlikely. For example, the following governmental agencies

have responsibility for the air pollution sources or programs indicated:

Governmental Agency	Source Program
U.S. Environmental Protection Agency (EPA)	New Motor Vehicles Stationary Sources
U.S. Federal Aviation Administration (FAA)	Aircraft
California Air Resources Board (CARB)	New Motor Vehicles In-Use Motor Vehicles
Bay Area Air Pollution Control District (BAAPCD)	Stationary Sources
Metropolitan Transportation Commission (MTC)	Regional Transportation Planning
Transit Districts	Transit Services
CALTRANS	Highways/Car pooling
Association of Bay Area Governments (ABAG)	Regional Comprehensive Planning
County and Local Governments	Local development

Note: This listing is intended to be illustrative only of the range of agencies involved in air pollution control programs. It is by no means intended to be comprehensive.

EMTF Action:

Seek clarification from the California Air Resources Board and Environmental Protection Agency regarding the plan approval process as it pertains to the AQMP.

ORGANIZATION AND BUDGET

In addition to guiding future actions in air pollution control, the AQMP is to coordinate air quality planning activities for the region. Due to the divergent mandates and responsibilities of the agencies involved in air quality planning, the AQMP program requires active participation by a number of agencies. The AQMP program is a cooperative planning effort with clear specification of agency labor and shared responsibility among those agencies involved.

To this end, the former AQMP-Policy Task Force adopted a resolution encouraging formation of a "joint technical staff" to conduct development of the AQMP. To facilitate formation of such a team, memoranda of understanding or joint powers agreements were recommended. At a minimum, the joint technical staff was to be represented by ABAG, BAAPCD, and MTC.

The basic philosophy behind the "joint technical staff" approach is to utilize the best available personnel (regardless of agency representation) and resources to undertake the AQMP preparation. The approach is designed to draw upon a wide spectrum of technical and planning expertise. The involvement of key regional agencies in the planning process will also ensure that the respective agency's perspectives are represented throughout.

As part of the work programming efforts and in an attempt to further define the respective agency roles and levels of involvement in development of an AQMP, the following arrangements have been made:

- California Air Resources Board (CARB) - Providing direct participation and support in developing the AQMP. Other CARB staff will continue to review and monitor work progress to ensure the technical validity of the analysis. Both types of involvement are being funded by EPA.

- Bay Area Air Pollution Control District (BAAPCD) - A contract with ABAG facilitating BAAPCD involvement in the joint technical staff has been signed. The BAAPCD will provide technical assistance in many areas of AQMP development.

- <u>Metropolitan Transportation Commission (MTC)</u> - A contract with ABAG specifying MTC's involvement in the AQMP has also been signed.

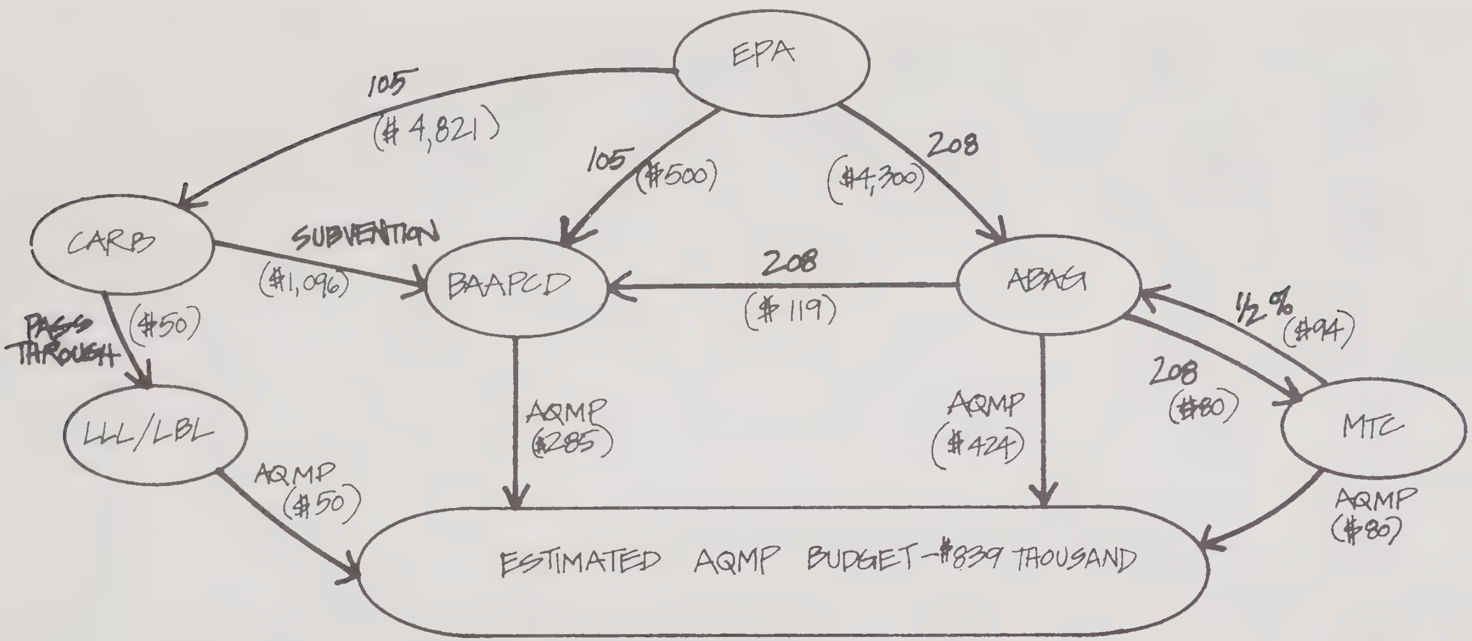
- <u>California Department of Transportation (CALTRANS)</u> - CALTRANS is actively participating in the AQMP planning process, including participation on the AQMP Joint Technical Staff.

- <u>Lawrence Livermore Laboratory (LLL)</u> - A contract is currently being negotiated between the Lawrence Livermore Laboratory and the California Air Resources Board to provide specialized assistance to the joint technical staff. LLL staff will assist in the use and interpretation of LIRAQ, a computer-based model of air quality in the Bay Area.

Two additional groups provide review and guidance to the joint technical staff. These are the AQMP Advisory Committee, and the Interagency Management Group. The AQMP Advisory Committee is composed of technical and policy representatives from private industry, academic institutions, and other public agencies in the Bay Area. The Interagency Management Group consists of representatives from the executive levels of ABAG, MTC, and BAAPCD. While both of these groups perform overlapping review and guidance functions, the advisory committee functions more as a sounding board for ideas, technical assumptions, and analytical techniques, while the management group focusses on resolving program management problems.

Finally, the budget for the AQMP is summarized in Exhibit 1. As may be seen from this illustration, AQMP funding is quite complex. The point to be drawn from this is that 208 funding is in reality contributing only a part of the total funds being used to prepare the AQMP.

EXHIBIT 1. AQMP FUNDING
(THOUSANDS OF DOLLARS)



LEGEND

105 - SECTION 105 OF CLEAN AIR ACT OF 1970
208 - SECTION 208 OF FEDERAL WATER POLLUTION CONTROL ACT OF 1972
PASS-THROUGH - EPA DESIGNATED PASS THROUGH TO LOCAL ORGANIZATIONS
SUBVENTION - CARB PASS THROUGH TO LOCAL APCD'S
LLL-LBL - LAWRENCE LIVERMORE LABORATORY / LAWRENCE BERKELEY LABORATORY
1/2% - MTC PASS THROUGH FROM FEDERAL HIGHWAY ADMINISTRATION

NOTES:

1) FIGURES SHOWN FOR AGENCIES NOTED ARE PARTIAL BUDGETS AND DEAL ONLY WITH GENERAL SOURCES OF THESE REVENUES

2) BUDGET IS APPROXIMATE SINCE CERTAIN BUDGETS ARE FOR ONE YEAR WHILE OTHERS ARE FOR TWO YEARS.

3) IN ADDITION TO DIRECT FUNDING FOR AQMP SUPPORT, EPA, CARB, & CALTRANS ARE CONTRIBUTING "IN-KIND SERVICES" STAFF SUPPORT TO THE PROGRAM

4) ABAG SUPPORT TO THE PROGRAM COMES UNDER THREE CATEGORIES:
- MTC 1/2% FUNDS — $94,000 — AQMP PLAN DEVEL.
- EPA 208 FUNDS — $330,000 — AQMP PLAN DEVEL.
- ENVIRONMENTAL MANAGEMENT PROGRAM (EMP) SUPPORTING SERVICES: (INSTITUTIONAL/FINANCIAL; PUBLIC PARTICIPATION; ASSESSMENT/EVALUATION; PROJECTIONS; LOCAL POLICY COLLECTION; DATA MANAGEMENT; AND PLAN INTEGRATION & ADMINISTRATION). THESE TASKS SUPPORT ALL EMP MANAGEMENT PLANS.

FINAL PRODUCT

The AQMP will consist of a set of policies and actions which will lead to the attainment and maintenance of air quality standards as expeditiously as practicable. These policies and actions will be directed toward reducing air pollutant emissions from both stationary and mobile sources. The control strategies are likely to include both direct emission controls and land use and transportation controls. The primary task of the EMTF will be to decide on the nature, severity, and extent of such controls.

A series of alternative control strategies will be developed by the AQMP-Joint Technical Staff with the assistance of the AQMP Advisory Committee. These strategies will then be evaluated with respect to several criteria:

- effectiveness in improving air quality
- direct economic costs
- indirect economic costs and social impacts
- legal, institutional, and financial requirements

The results of this evaluation will be presented to EMTF for deliberation and selection of the strategy which will then become the substance of the AQMP.

Without knowing at this time specifically what the strategy alternatives might look like, some general characteristics can be identified. First, there will be at least one strategy which will be demonstrated to result in attainment of air quality standards by 1985 and maintenance of those standards through the year 2000. A second strategy will be formulated which will result in attainment of air quality standards by the year 2000. It is anticipated that this latter strategy will also result in lesser social and economic costs to the region than the first strategy.

Each strategy developed will consist of direct emission controls and indirect land use and transportation related measures. The differences between the strategies will be in the degree of emphasis placed on each area of possible control. For example, one strategy may contain provisions for extensive short term control over existing industrial pollutors while adding greater flexibility to new source review requirements. The counterpart to such a strategy

would be to proceed more deliberately in controlling existing sources while maintaining or strengthening the current New Source Review rule.

A second example would be a strategy which relies heavily on increasingly stringent motor vehicle emission control requirements in combination with a minimal transportation control program (e.g., a mandatory annual vehicle inspection and maintenance program). The counterpart to this strategy would be an aggressive land use and transportation management program with an emphasis on enforcement of existing motor vehicle emission standards.

Alternative strategies will be developed to clearly identify the tradeoffs involved. It is quite possible EMTF will eventually select a strategy which is composed of portions of several different strategies presented for consideration. Finally, each strategy will be accompanied by an identification of the agencies responsible for implementation of the individual control measures. Where new legislation is required to implement a program, these needs will be identified.

PROGRESS AND SCHEDULE

Progress in developing the AQMP has been slow in the initial phases as a result of many factors. The emphasis during this period has been on developing working relations between the participating agencies, and on preparing the base data and analysis tools which will be used. As a measure of progress on each of these fronts, the following summary is provided:

Development of Working Relationships

- The Joint Technical Staff initiated meetings in August, 1976, and has met seventeen times through 2/18/77. Technical assumptions, data bases, basic analysis tools have been agreed upon, although this is viewed as matter requiring continuing attention as the program evolves. The Joint Technical Staff is currently compiling and reviewing candidate control measures to be considered in the AQMP. In addition, the data and models required to evaluate the alternative strategies are being prepared.

- Contracts have been signed with BAAPCD and MTC for program support.

- The AQMP Advisory Committee has met three times and reviewed the products produced thus far. In the immediate future, this body will assist the Joint Technical Staff in the preliminary screening of candidate control measures.

- The Interagency Management Group has met twice and has functioned as a vehicle for direct interagency communication at the executive level.

- A contract is currently being negotiated between the Lawrence Livermore Laboratory and the Air Resources Board to provide more direct, intensive assistance to the Joint Technical Staff in the use of the LIRAQ air quality model.

Products

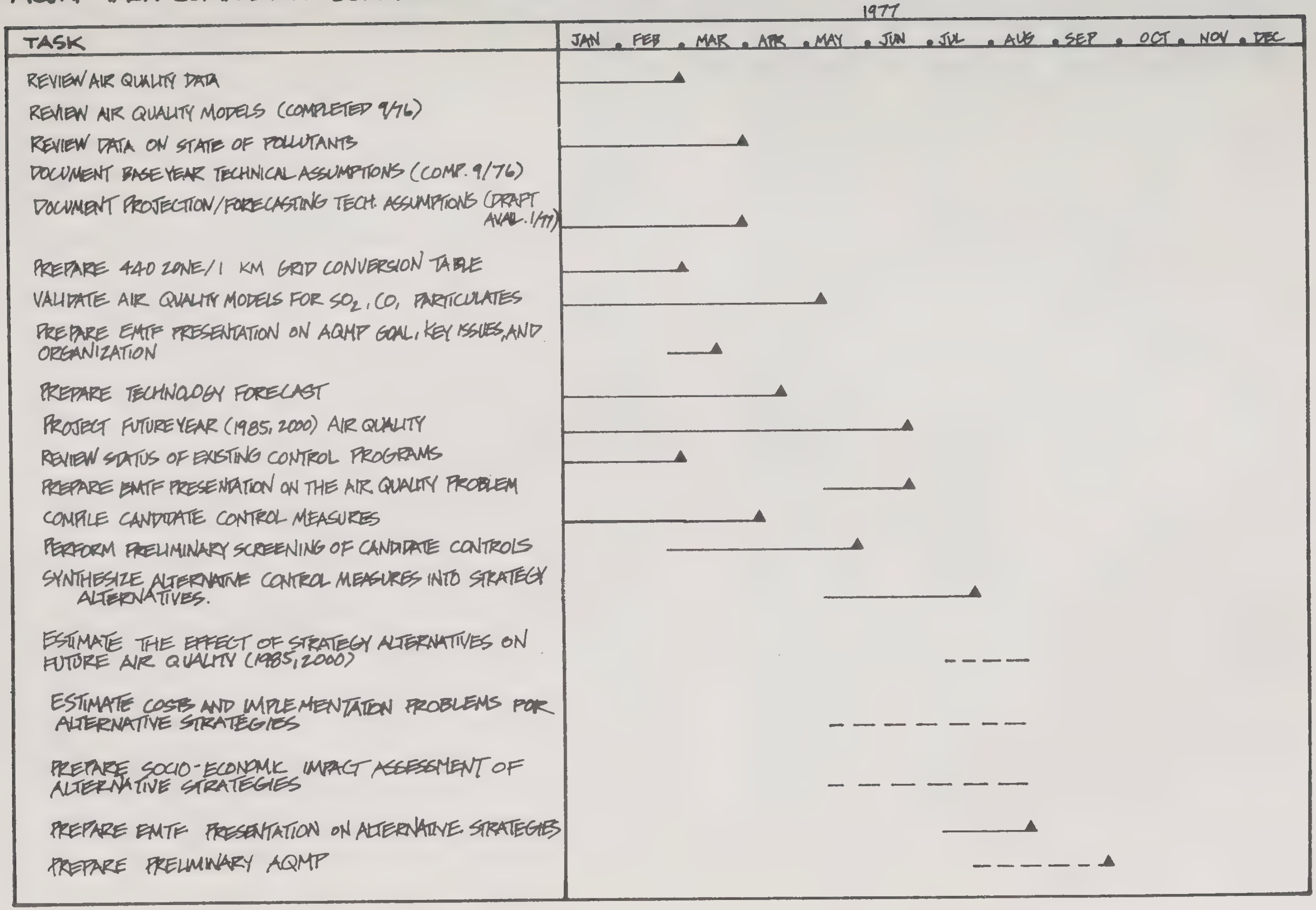
- "Air Quality Maintenance Plan Work Program for the Joint Technical Staff," November, 1976

- AQMP, Issue Paper 1, "Air Quality Modeling for the San Francisco Bay Region," September, 1976
- AQMP, Tech Memo 1, "Base Year Selection and Technical Assumptions," September, 1976
- AQMP, Tech Memo 2, "Projections/Forecasting: System Description and Technical Assumptions," December, 1976
- AQMP, Tech Memo 3, "Air Quality Past and Present," March, 1977 (draft in preparation)
- AQMP Tech Memo 4, "Status of Existing Control Programs Related to Air Quality," March, 1977 (draft in preparation)

The schedule for completion of specific tasks has been recently updated by the Joint Technical Staff. This schedule is summarized in Exhibit 2. Problems being encountered by staff in attempting to meet the schedule are discussed in the next section.

EXHIBIT 2

AQMP TASK COMPLETION SCHEDULE (REVISED 2/11/77)



PROGRAM PROBLEMS

The approach being taken to develop the AQMP is unique and based on the concept of shared responsibility and intergovernmental cooperation. This approach has led to some program management problems, four of which are cited below:

1) The program is behind schedule

The program has fallen behind schedule for a number of reasons. ABAG contracts for MTC and BAAPCD services were executed six to seven months late. Certain tasks are slipping behind schedule and the general level of coordination required to manage the program has been underestimated. (The decision to do so resulted from general State and federal support that such an integrated approach to environmental decision making was highly desirable.)

As a result, the deadline for an approvable AQMP is slightly different than that for the 208 plan. Finally, from the beginning the schedule outlined was ambitious. Both BAAPCD and MTC have repeatedly questioned how realistic the schedule proposed was.

2) The level of effort and commitment appear low

Based on information received to date, the overall level of expenditures for AQMP are low. ABAG expenditures are approximately on schedule. BAAPCD and MTC expenditures appear low. As a result, maintaining the current pace of the program may result in ABAG exceeding its budget (i.e., if the program were to be significantly delayed). In the beginning, and to some extent now, the staff assignments from participating agencies is unclear. Many, if not all of the Joint Technical Staff members, have other responsibilities. As a result, the level of participation and commitment to AQMP is uncertain.

3) Delivery of AQMP products in an efficient manner has posed problems.

The concept of a Joint Technical Staff with shared responsibility emphasizes cooperation. By design, such

an approach is inefficient. Currently, all AQMP products undergo review by the Advisory Committe, participating agencies individually, and the Joint Technical Staff collectively. Such a process is quite time consuming and has resulted in delayed delivery of AQMP products.

4) Project control is rather limited

Since 208 funds only a portion of the AQMP, project management is rather limited. In general, the level of project management control is not commensurate with the responsibility. Again, the approach being taken in AQMP has not been designed for maximum efficiency.

EMTF Action: Two options are available for discussion and possible action: 1) Reschedule the AQMP based on the latest information available concerning probable completion dates of AQMP tasks. A rough estimate of the implications of such a decision is that the AQMP will be 6-12 months late. This option maintains the status quo. 2) Affirm the desire to maintain the AQMP as part of the Environmental Management Plan, including delivery of the AQMP on the original schedule. This option would require substantial changes to the present mode of operation.

ADVISORY COMMITTEE COMMENTS

To date, the AQMP Advisory committee has met three times (September, November, and January). The first meeting was an introduction to the AQMP program, and included discussion of two technical papers concerning base year selection and air quality models. The second meeting centered around presentation and discussion of the methodology to be employed for forecasting future air quality. These aspects of the program have been summarized in the following papers:

- AQMP Tech Memo 1, "Base Year Selection and Technical Assumptions"
- AQMP Issue Paper 1, "Air Quality Modeling for the San Francisco Bay Region"
- AQMP Tech Memo 2, "Projection/Forecasting: System Description and Technical Assumptions" (draft)

The third meeting focussed on a continued discussion of the forecasting system as well as a discussion of the "technology forecast" to be conducted as part of the AQMP. In essence, staff will be polling experts in air pollution control technology to determine the potential for improvement in such technology through the year 2000.

Table 2 summarizes advisory committee comments received as of the third meeting; together with staff responses. Comments received during and subsequent to the third meeting will be addressed when the final version of Tech Memo 2 is prepared.

The next meeting of the AQMP Advisory committee will be on March 17th. The focus of discussion will be on alternative control measures. In addition, drafts of Tech Memo 3, "Air Quality Past and Present," and Tech Memo 4, "Status of Existing Controls Related to Air Quality," will be reviewed.

TABLE 2
SUMMARY OF AQMP TECHNICAL ADVISORY COMMITTEE COMMENTS

COMMENT	RESPONSE
There is very little said about the meteorological data base. Speaking solely with respect to the LIRAQ data base, the July and August periods in 1973 are available at LBL... Data exist in the NSF data base for 1974 that could probably be developed into available days with no more than perhaps a month's work per day.	This information has been incorporated in the paper.
There needs to be a statement explaining why one year's pollution. Although one can use one year's pollution. Although weather patterns are believed to recur, it would also be useful to classify each day by its characteristic frequency on the Larsen air quality curve. This would likely help in assembling a "typical" meteorological year from the available days.	A year is the basic unit used in control plan development for three main reasons: first, air pollution problems recur on a seasonal basis, and a full year is required to sample the full range of problems which occur (e.g., oxidant is a summer/autumn problem, while CO and SO_2 problems are most severe during the winter months); second, the year is a convenient and commonly used unit for summarizing data such as population, economic activity, transportation/traffic data, emission inventory, etc; and third, the state and federal mobile source control programs are implemented with increasing stringency on a model year by model year basis. The issue of recurring weather patterns and the validity of using past meteorology to predict future air quality will be addressed in a sub-sequent paper.

COMMENT	RESPONSE
The present emission data base for LIRAQ does have SO_2 and particulate information. We have run SO_2 in the LIRAQ models at LLL--and this should be available at LBL by next spring.	This information has been incorporated in the issue paper on Air Quality Modeling.
It seems unrealistic to prepare source inventories for a single day.	Appropriate qualifications have been inserted in that discussion.
The use of the ARB organic compound reactivity classification scheme may require some discussion since it is not entirely compatible with LIRAQ input data requirements.	Ordinarily, one would prefer to use the most recent year for which a complete air quality and emission inventory data base can be compiled. This is because control programs are being implemented continuously, and the latest data yields a more realistic picture of the effectiveness of existing program. This, in turn, provides a more realistic picture of how much more needs to be done, provided that the latest year is not unusual from an air pollution standpoint. 1975 is neither unusually poor nor unusually good meteorologically. 1973 is suggested as an alternative only because data appropriate for 1973 has previously been compiled and prepared for LIRAQ use. Thus, less resources would be required for the analysis if 1973 is used as the base year. A secondary factor in favor of 1975 as the baseyear is the fact that the other plans related to 208 as well as MTC's transportation data base are more compatible with a 1975 baseyear.

C O M M E N T	R E S P O N S E
The concept of developing a regional emissions inventory for carbon monoxide (CO) does not appear to offer much promise if viable and effective control strategies are to be developed. High concentrations of CO are usually related to factors such as surrounding building height, street configurations, traffic signalization and traffic congestion. Therefore, it is recommended that ABAG undertake a study of traffic patterns and other conditions in the areas where high CO concentrations are currently being recorded. Control strategies for similar areas can then be developed using these areas as examples.	The factors influencing high CO concentrations as well as the approach to the analysis are quite accurately stated, and in fact represent our approach to the CO analysis. However, a regional CO inventory is still necessary in order to compute the background CO levels upon which more localized factors operate. Without the regional analysis, assumptions concerning the appropriate urban background CO level would have to be made.
I find the choice of base years poor. 1975 was incredibly dry and hardly meteorologically average in any way. 1973 was the energy crisis year. Why not 1970?	See response to previous comments. 1975 may have been dry, but this had little affect on air quality as reported by the Bay Area APCD's monitors. The number of wet days over the course of a year is small, even under normal rainfall conditions and is thus not a significant factor.
Projections of vehicle-miles-travelled (VMT) may be more sensitive to cohort age group projections rather than aggregate population projections.	Population projections prepared by ABAG are based on a cohort/survival technique for each age group. This information cannot be used by MTC at this time in projecting VMT. MTC uses household size as a surrogate variable in this instance.

C O M M E N T	R E S P O N S E
The baseyear ought to be as far back as good data would permit.	See the response to previous comments. The problem here is that the "goodness" of the data improves each year as we become more sophisticated in our techniques. Hence, the further back we go, the less precise our data is.
The limitations of stochastic models seem understated. It is not proven that if changes are uniform over a region, the predicted changes will be valid. Further, stochastic models neither explain why changes occur nor indicate the different ways in which control strategies might influence air quality. Emission uncertainties and lack of knowledge of what's happening between observation stations can also pose problems for stochastic models. Finally, rollback is not proven for oxidants - Eschenroeder pointed out some indications on his last visit to LLL that rollback missed the sign of the change. This is not to say deterministic models don't have limitations, although the general statement that such models have "uncertainties in virtually all aspects..." is too vague and probably an overstatement. Specifics are needed.	There is a wide variety of factors which contribute to the limitations of both deterministic and stochastic models. These include inaccuracies and uncertainties in both input and the assumptions inherent in each modeling approach. A more detailed discussion of such limitations would, of necessity, be conducted in highly technical terms, and would communicate little further information. The fact remains that we will be applying the best techniques possible. We can depend upon those who are equally if not better equipped to apply the models to ensure that the results are interpreted appropriately.

COMMENT	RESPONSE
In summary on this matter, this paper needs a realistic assessment of model limitations for both stochastic and deterministic models. This could (and should) be covered in the model descriptions at the end of the paper.	
I was rather surprised that there is no reference to more specialized photochemical models. Certainly for point source, reactive plumes and probably for some special projects, models such as an improved DIFKIN and a plume model may be necessary.	No reactive plume or special project analyses are contemplated for photochemical oxidant, at least for this initial AQMP effort. Since oxidant is a regional problem demanding broad-based regional control strategies, examination of the intricacies of the effects of individual sources is inappropriate. Further, reactive plume models have not been validated in a multiple-source, regional context. Additional work on a research level would be required before such analyses could be applied to the development of real-world control strategies.
A cost-effectiveness table showing the relative cost of running a model compared to its output should be developed.	If each of the models had previously been applied to the Bay Area on an equal basis, such a table could be developed. Unfortunately, such is not the case. Each model has been applied in different situations, to different pollutants and source distributions, etc. Thus, only generalized statements of cost and output have been added to the paper.

C O M M E N T	R E S P O N S E
In addition to representing state-of-the-art in air quality modeling, the model must be technically acceptable to the EPA who will be ultimately responsible for approving the AQMP.	EPA is reviewing AQMP Issue Paper 1, and barring unforseen developments, we expect no opposition to the use of the models identified. EPA has previously stated in a letter to John Tuteur of the EMTF that LIRAQ is an acceptable model for AQMP purposes subject to the condition of proper input data preparation and interpretation of results.

APPENDIX A

SAN FRANCISCO BAY AREA
POLICY TASK FORCE RESOLUTION #1

RE: **Affirmation of the San Francisco Bay Area as an Air Quality Maintenance Area**

WHEREAS, the Environmental Protection Agency promulgated regulations on June 18, 1973 (40 CFR 51.12) requiring states to amend their State Implementation Plans to identify areas which have the potential to exceed the National Ambient Air Quality Standards in the period from 1975-85.

WHEREAS, on June 13, 1974, the Air Resources Board adopted Revision 5 to the State Implementation Plan which identified the nine counties of the San Francisco Bay Area Air Basin as an Air Quality Maintenance Area for particulate matter, oxidants, and sulfur dioxide; and

WHEREAS, EPA confirmed this designation on September 9, 1975 (40 CFR 52.267) and

WHEREAS, the Phase I Policy Task Force, selected by citizens and elected officials of the Bay Area, has received and reviewed the Air Quality Maintenance Planning staff report citing the methods and assumptions used by the Air Resources Board in that identification, and

WHEREAS, the Policy Task Force believes it is desirable to achieve air quality equal to or better than Federal and State standards to the extent that the achievement of such levels of air quality can be consistent with other social and economic needs of the region, and

WHEREAS, the Policy Task Force has heard substantial evidence which indicates that, although air quality will generally tend to improve until approximately 1980, there is a real possibility that growth and development might reverse short-term improvements even with technical controls, and that air quality standards for particulate matter, oxidant, and carbon monoxide are not being met at present in the Bay Area, and may not be met in the long term. Now therefore, be it

RESOLVED, that the Policy Task Force concurs in the designation of the San Francisco Bay Area as an Air Quality Maintenance Area and further recognizes that the potential for exceeding the federal and state ambient air quality standards requires our support of the air quality maintenance planning process and its examination of not only the pollutants for which the Bay Area was designated but all pollutants for which a standard has been set and which may, if exceeded, threaten the health and welfare of the people of this region; and

BE IT FURTHER RESOLVED, that the Phase I Policy Task Force acknowledges that, upon completion of a reanalysis of the area boundaries and the identification of institutional mechanisms, air quality considerations in the San Francisco Bay Area necessitate that we commence a long-term planning process in Phase II to develop and implement an Air Quality Maintenance Plan to insure the achievement and continued maintenance of healthy levels of air quality in accordance with federal and state ambient air quality standards.

Unanimously approved on November 12, 1975.

SAN FRANCISCO BAY AREA
POLICY TASK FORCE RESOLUTION #2

RE: Transfer of responsibility for Phase I AQMP to the Environmental Management Task Force, a committee of the Association of Bay Area Governments.

WHEREAS: the Environmental Protection Agency promulgated regulations on June 18, 1973 (40 CFR 51.12) requiring states to amend their State Implementation Plans to identify areas which have the potential to exceed the National Ambient Air Quality Standards in the period from 1975-85; and

WHEREAS, on June 13, 1974, the Air Resources Board adopted Revision 5 to the State Implementation Plan which identified the nine counties of the San Francisco Bay Area Air Basin as an Air Quality Maintenance Area for particulate matter, oxidants, and sulfur dioxide; and

WHEREAS, EPA confirmed this designation on September 9, 1975 (40 CFR 52.267); and

WHEREAS, the Phase I Policy Task Force, selected by citizens and elected officials of the San Francisco Bay Area, has accepted responsibility for completing Phase I of an Air Quality Maintenance Plan; and

WHEREAS, Phase I of an Air Quality Maintenance Plan is defined to include the following six tasks:

(1) Examination of the air quality problems of the San Francisco Bay Area Air Basin;

(2) Development of an initial Air Quality Maintenance Plan Policy framework;

(3) Review of various air quality improvement strategies for the Phase II planning process;

(4) Recommendation of an appropriate institutional framework to develop and implement an Air Quality Maintenance Plan;

(5) Identification of resources for the Phase II planning process;

(6) Development and approval of a Phase II work program; and

WHEREAS, the Phase I Policy Task Force and Phase I Technical Advisory Committee are currently engaged in accomplishing the six tasks; and

WHEREAS, the Association of Bay Area Governments has established an Environmental Management Task Force to complete a planning process which will guide the development of an Areawide Wastewater Management Plan required under S.208 of the Federal Water Pollution Control Act Amendments of 1972 and an Air Quality Maintenance Plan required by the Clean Air Act of 1970; and

WHEREAS, the Environmental Management Task Force is comprised of elected officials and citizens very similar to the Phase I Policy Task Force; and

WHEREAS, the Phase I Policy Task Force believes that the remainder of the Phase I planning process can be more efficiently carried out under the auspices of the Environmental Management Task Force. Now therefore, be it

RESOLVED, that the Phase I Policy Task Force hereby transfers the responsibility for completing Phase I of an Air Quality Maintenance Plan, including the completion of the six aforementioned tasks, to the Environmental Management Task Force, a committee of the Association of Bay Area Governments; and

BE IT FURTHER RESOLVED, that upon acceptance of said responsibility by the Environmental Management Task Force, the Phase I Policy Task Force will immediately cease to exist, and

BE IT FURTHER RESOLVED, that upon acceptance of said responsibility by the Environmental Management Task Force, the Phase I Technical Advisory Committee will report to the Environmental Management Task Force, and

BE IT FURTHER RESOLVED, that the Environmental Management Task Force shall continue and build upon the work of the Phase I Policy Task Force through the use of a joint technical staff including the use of appropriate personnel from the Association of Bay Area Governments, the Bay Area Air Pollution Control District, the Metropolitan Transportation Commission and other agencies and individuals with recognized expertise. To facilitate the formation and support of this joint staff group, interagency arrangements such as memoranda of understanding and joint powers agreements are encouraged. This joint staff group shall coordinate and supervise all air quality consultant work subject to the direction of the Environmental Management Task Force.

Passed Unanimously January 14, 1976

ENVIRONMENTAL MANAGEMENT PROGRAM

AIR QUALITY MAINTENANCE PLAN BRIEF NO. 2

ALTERNATIVE AIR QUALITY STRATEGIES

EUGENE Y. LEONG

PREPARED FOR THE

ENVIRONMENTAL MANAGEMENT TASK FORCE

JUNE, 1977

CONTENTS

INTRODUCTION

This is the second of four briefs covering the Air Quality Maintenance Plan (AQMP). It begins with a brief description of existing air pollution control programs. Building upon this background, a listing of candidate control measures is developed. Because of the large number of possible control measures, a preliminary screening has been conducted to pare down the initial listings. The reduced list of candidate control measures is used to construct alternative air quality strategies.[1] These strategies are presented for EMTF review and comment.

Originally the second AQMP brief was to describe the air quality problems in the Bay Area. This brief has now been rescheduled for August 1977 at the third AQMP briefing. The rescheduling has been primarily for two reasons:

- A number of EMTF members and AQMP staff have felt the control measures and strategies need to be aired as soon as possible to stimulate early debate and to provide staff with some direction in formulating the strategies for testing.

- The recently revised AQMP schedule targets completion of the baseline air quality projections[2] for the end of June--too late for the EMTF presentation.

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[1]"Control Measure" is used to describe an individual proposal, e.g. inspection and maintenance. "Control strategy" is used to describe a combination of two or more control measures, e.g. improved transit service, carpooling program and parking surcharges.

[2]Existing air quality problems have been documented in AQMP/Tech Memo 3, "Air Quality: Past and Present," March, 1977. Air Quality projections to the year 2000, based on existing trends and no additional control programs beyond those currently scheduled, should be completed in June, 1977.

ISSUE:

The AQMP-Joint Technical Staff, with assistance from the AQMP-Advisory Committee, has spent considerable time and effort documenting existing air pollution control programs and potential future controls. Because of the large number of alternative control measures under consideration, staff has conducted some preliminary screenings of these measures.

To assist in further organizing the alternative measures, four basic air quality strategies are identified. These basic strategies (see Figure 1, page 23)--lifestyle change, energy conservation, everybody pays, and technology dependence--represent a wide range in strategy options.

As an example of how different sets of control measures for each strategy are possible, Figure 1 presents three sets of controls, representing different degrees of "stringency," for each strategy. The twelve strategies shown are illustrative of the strategies being analyzed by staff for their technical, social, and economic impacts on the region.

EMTF ACTION:

EMTF is asked to review the control measures presented in this brief. Table 4, page 21, gives a listing screened by the AQMP-Joint Technical Staff on control measures which appear most promising for air quality improvement.

EMTF is asked to approve this summary of control measures for use in developing alternative strategies. EMTF is also asked to approve the four basic air quality strategies presented in Figure 1 as a representative range of strategies to be analyzed. These basic strategies are lifestyle change, energy conservation, everybody pays, and technology dependence. (Note: EMTF is not being asked to approve the twelve sample sets of control measures shown in Figure 1.) Approval of the four basic strategies and a summary of control measures will permit the AQMP-Joint Technical Staff to continue developing and refining specific strategies which appear most effective for satisfying the air quality objectives of the program.

EXISTING AIR POLLUTION CONTROL PROGRAMS[3]

The air pollution problem in the San Francisco Bay Region results from a wide range of human activities. These activities, whether related to our needs for manufactured goods, transportation, or electric power generation, produce emissions of a variety of pollutants. Each pollutant, in turn, produces a unique set of health hazards, agricultural crop damages, and other effects. Thus, both the number of pollutants and the variety of source types make air pollution control a complex task requiring an equally varied arsenal of regulatory tools. This section summarizes existing air pollution control programs. These controls are the foundation of the Air Quality Maintenance Plan.

STATIONARY SOURCE EMISSION CONTROLS

In the San Francisco Bay Region, the Bay Area Air Pollution Control District (BAAPCD) has been empowered to control air pollution from stationary sources. Since its formation in 1955, the District has developed air pollution control programs for many categories of stationary sources.

To date the BAAPCD has enacted eight regulations, six of these affect stationary sources and two deal with motor vehicle emissions. Some of the regulations directly control air pollution by limiting the emissions of specific pollutants, either on a mass flow rate or concentration basis. Other regulations indirectly control pollutants by curtailing open burning, new source construction and expansion of existing stationary sources. Some sections deal specifically with emissions of odorous substances and other limit the density of smoke which may be emitted to the atmosphere. The regulations of the BAAPCD have been expanded and modified through the years, and are generally acknowledged to be among the most stringent in the United States. A brief description of present regulations follows.

Regulation One, adopted in 1957, bans backyard trash burning and dump fires. It lists allowable types of fires and limits agricultural burning to favorable meteorology days designated "burn days" by the District.

Regulation Two, first adopted in 1960, has eighteen different divisions. It includes controls on particulate matter (smoke particles and dust), sulfur compounds, lead, nitrogen oxides, and odorous substances from industrial and commercial sources. Permit and new source review requirements are also included in Regulation Two. The requirement for vapor recovery systems at service stations is part of the permit regulation.

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[3]For more details see AQMP/Tech. Memo 4, "Status of Existing Controls Related to Air Pollution," March 1977.

The District's permit requirements, set out in Division 13 of Regulation Two, require anyone wishing to build or expand a source that emits air contaminants to first apply to the BAAPCD for a permit to build, and submit plans and specifications for evaluation by District engineers. Permits to build or modify will be denied if it is determined that the project would not meet any of the District's emission requirements or would cause any air quality standard to be exceeded in the vicinity of the proposed site. A second evaluation is required after the source is built before it can obtain a permit to operate. Division 13 also requires vapor recovery controls for service stations.

Regulation Three, originally promulgated in 1967, was developed to control emissions of organic compounds, in particular "reactive" organics which are relatively quick to react with nitrogen dioxide in the atmosphere and form photochemical oxidant. Olefins, substituted aromatics, branched chain ketones and trichloroethylene are examples of reactive organic compounds controlled under this regulation. Regulation Three affects the formulation, storage, shipment and use of such materials as solvents, paint, gasoline and ink.

Regulation Four, 1971, does not deal with stationary source controls. Now obsolete, it required installation of crankcase emission control devices on certain automobiles.

Regulation Five, adopted in 1974, defines three levels of air polltuion episodes and specifies actions to be taken by the Air Polltuion Control Officer. Certain corrective control measures are invoked to discourage further buildup of contaminants in the atmosphere. Included in Regulation Five is a requirement that source operators submit, in advance, standby plans for reducing emissions during air pollution episodes.

Regulation Six, 1974, does not affect stationary sources. It gives members of the BAAPCD vehicle patrol authority to arrest individuals observed to be violating those provisions of the vehicle code relating to automotive emissions.

Regulation Seven, 1974, sets emission standards for new or modified sources of air pollution, following EPA guidelines. These sources inlcude fossil fuel power plants, larger incinerators, cement plants, acid plants, refineries, smelters and steel plants.

Regulation Eight, 1974, establishes limits for the emission of asbestos, beryllium and mercury, defined as hazardous pollutants by the EPA. Sources of asbestos are allowed no visible emissions. The beryllium standard limits emissions to not more than 10 grams per 24-hour period. For mercury the limit is no more than 2300 grams/24 hours.

Because of the historical development process, the present system of regulations has become somewhat unwieldy. A complete reorganization is presently being studied and is expected to make the regulations easier to understand and apply.

MOTOR VEHICLE EMISSION CONTROLS

The Air Resources Board (ARB) is the State agency responsible for coordinating both State and Federal air pollution control programs in California. This responsibility includes regulation of pollutant emissions from motor vehicles and coordination of local programs for stationary source control.

Due to the severity of air pollution problems in California, the Federal government gives the State the option of enforcing motor vehicle emission standards which are more stringent than Federal emission standards. Thus, while the Environmental Protection Agency takes primary responsibility for motor vehicle emissions control, the ARB can and has adopted and enforced emission standards more stringent than required at the Federal level. This section summarizes ARB responsibilities for mobile source control.

The ARB currently has regulations which control emissions from light, medium and heavy duty gasoline powered vehicles, diesel powered trucks and buses, and motorcycles. In addition, the ARB has in effect various regulations and procedures to ensure that emission standards are met. Table 1 presents current vehicle emission standards.

Table 1. Current State Vehicle Emission Standards

Model Year	Vehicle Category	HC	CO	NO_x
78-	Passenger cars	0.41 gm/mi	9.0	1.5
80-81-	Passenger cars			1.0
78-	Lt. Duty Trucks (All)	0.9	17	2.0
80-	Lt. Duty Trucks (EIW $<$ 4000 lbs)	0.41	9.0	1.5
80-	Lt. Duty Trucks (EIW $\geq$ 4000 lbs)	0.50	9.0	2.0
81-	Lt. Duty Trucks (EIW $<$ 4000 lbs)	0.41	9.0	1.0
81-	Lt. Duty Trucks (EIW $\geq$ 4000 lbs)	0.50	9.0	1.5
78-80-	Med. Duty Vehicles	0.9	17.0	2.3
81-	Med. Duty Vehicles (EIW $<$ 4000 lbs)	0.41	9.0	1.0
81-	Med. Duty Vehicles (EIW 4000-5999lbs)	0.50	9.0	1.5
81-	Med. Duty Vehicles (EIW $>$ 6000 lbs)	0.60	9.0	2.0
78-	Motorcycles	10.0 gm/km		
80-	Motorcycles	5.0	(no standards)	
82-	Motorcycles	1.0		

EIW= Equivalent Inertial Weight

TRANSPORTATION CONTROLS

The following transportation control projects are currently operating in the San Francisco Bay Area. Some were required as elements of the Transportation Control Plan, an air quality control plan prepared and adopted by MTC to reduce and/or discourage auto travel; others are the result of regional transportation planning.

1. Ramp and Mainline Metering:

I-580 - Beaumont Avenue east bound on-ramp in Oakland;

I-280 - 5 north bound on-ramps between Winchester Road and Route 85 in San Jose. Wolfe Road on-ramp provides by-pass for buses and carpools of 2 or more.

Rt 101 5 north bound on-ramps between Capitol Ave. and Route 17 in Santa Clara County;

Rt 17 Presently under construction; 23 north bound and south bound on-ramps between Route 9 and Route 101 in Santa Clara County;

Bay Bridge: In March 1974, an overhead metering system was installed just beyond the toll plaza at a cost of $350,000. This system has maximized the operational efficiency of the bridge.

The following two projects are scheduled to be advertised for bid in July 1977:

Rt 101 5 north bound on-ramps between Route 17 and Fair Oaks Blvd. in Santa Clara County;

Rt 101 Upgrade five north bound on-ramps between Capitol Ave. and Rt. 17.

2. Preferential Bus/Carpool Lanes on Freeways:

Rt 101 Marin County Exclusive Bus Lanes. In 1972, a 3.9 mile northbound contra-flow exclusive bus lane was opened just north of the Golden Gate Bridge for use during the period 4 to 7 p.m. Approximately 100 buses use the lane, carrying about 4500 persons. In 1974 the project was extended northerly an additional 3.8 miles when with-flow bus lanes were opened in both directions. Carpools were later allowed to use these lanes.

Rt 280 In October 1975, a two mile bus/carpool lane was opened on southbound I-280 in San Francisco from Sixth Street to approximately one-half mile south of Army Street. Approximately 200 carpools and 12 buses use this lane during the evening peak.

S.F. In San Francisco bus lanes are in operation on Post and Sutter Streets between Van Ness and Taylor. Approximately 60 buses use these lanes during the peak periods. Muni has reported improved schedule adherence. A bus lane has just opened along Mission Street.

3. Toll Incentives:

Bay Bridge - In December, 1971, with-flow carpool and bus lanes were opened at the westbound approach of the toll plaza. In

1975 carpool tolls were eliminated. During the 6 a.m. - 9 a.m. peak period, 430 buses and 2,200 carpools use the priority lane.

San Mateo-Hayward and Dumbarton Bridges - Toll free preferential lanes for buses and carpools were opened on both these bridges. Approximately 520 carpools and 40 buses use these lanes during commute periods.

Golden Gate Bridge - The Golden Gate Bridge District began allowing carpools to use the bridge toll-free in 1976. Approximately 1100 carpools use this lane daily.

Toll Revenues - AB 664 gave MTC authority over the level and use of tolls on the trans-bay bridges. MTC has recently proposed raising the tolls and using the excess revenue for transit.

4. <u>Carpool Matching Program</u>:

RIDES - is a program operated by Caltrans District 04 to promote carpooling in the San Francisco Bay Area. A survey conducted in 1975 indicated that approximately 5000 persons had formed carpools as a result of the program.

5. <u>Improvement of Transit Service</u>:

AC/BART - Coordinated Fare - The AC/BART transfer system provides for free transfers from BART to AC.

MUNI/BART Coordinated Fare - The MUNI/BART transfer system provides two tickets for MUNI bus rides for 25¢, a savings of one-half the full regular fare.

Santa Clara - Santa Clara Transit District was formed in 1972. Operations commenced in 1975 with 233 buses. The District also operated 9 buses for "Commute Specials" - these are used by some of the local businesses.

Bus Pre-emption - A bus pre-emption system is to be installed along a portion of Almaden Expressway. Twelve signalized intersections are involved. The traffic signal equipment is under construction.

San Mateo County - San Mateo Transit District was formed in 1974 and operations commenced in July 1976. Two hundred buses provide service to and within most cities in San Mateo County including a connecting service between the Daly City BART station and San Francisco Airport. Buses also serve Southern Pacific stations in the county.

Marin County - In 1970 Golden Gate Transit introduced a new ferry service between Sausalito and San Francisco. Additional service was added in December 1976 between Larkspur and San Francisco. Full service with four ferries will be achieved this year.

Napa County - Napa County introduced a Dial-A-Ride system which is designed to provide local transit service in three communities: St. Helena, Calistoga and Napa. The service is provided using one bus.

Sonoma - mini-bus operates in Sebastopol. Transit service in Santa Rosa is provided by 13 buses, which operate approximately 40 minutes apart.

Solano - In August 1975 the City of Fairfield implemented a Dial-A-Ride program using 5 vans. The service area is seven square miles with a population of 40,000.

AC Transit - AC Transit now provides contract city services in Concord, Pleasant Hill, and Moraga/Orinda. AC Transit also connects with Santa Clara County Transit District buses at Fremont BART station.

BART Feeder Express - BART Express Buses connect outlying East Bay communities with BART: Alamo, Danville, Dublin and San Ramon to Walnut Creek Station; Dublin, Pleasanton and Livermore to Hayward and Bayfair stations; Pleasant Hill, Martinez, Pittsburg, Antioch, Oakley and Brentwood to Concord Station; and Pinole to El Cerrito Del Norte Station.

6. Preferential Parking:

San Francisco - Caltrans is in the process of leasing 4 State parking lots for carpool use. There would be 580 stalls available, open only to carpools of 3 or more. The fee would be not more than $10/month.

The current programs provide the AQMP with valuable insight into future transportation control programs. The carpool incentives seem to be successful, as evidenced by the marked increase in carpooling activities. The transit additions have also been important, but the problems of financing future additions are becoming critical. Despite these incentives auto travel has not really decreased. This would indicate that some combination of auto restraints and more transit/carpool incentives is needed. This appears to be the most promising direction for the AQMP.

LAND USE/DEVELOPMENT CONTROLS

Land use controls have long been used to deal with localized air pollution problems. For example, residential areas are physically separated from industries emitting air pollutants in the general plans of cities and counties. Land development strategies--how government influences the growth of the region--are of more concern in the air quality maintenance plan, since the oxidant problem is regionwide in nature.

Land Development Policy as Currently Carried Out in the Bay Area

Land development policy is commonly used to represent the land development objective sought, and the term "policy instrument" is used to describe the technique for achieving the objective. The development policy in each locality is a function of what local governments--cities, counties,and service districts--are doing with their legal and fiscal tools to manage land development with essential urban services such as sewers, water, and roads. Information on the current operating policies of local agencies was inventoried in ABAG's 1976 Local Development Policy Survey.

Development policy in the local jurisdictions is more than the general plans of cities or counties. The general plans and zoning ordinances are supplemented by capital improvement programs, special tax programs (e.g. Williamson Act Agricultural Preserves), specialized regulations in hazardous areas (e.g. slope and flood area regulations), building permit allocation programs, and several other devices.

ABAG Series 3 Projections of Polulation, Employment and Land Use

ABAG has used its inventory of local development policy as the basis for its Series 3 Projections. Current local development policies were assumed to remain in force throughout the projection period. The implications of regional growth on current development policy are documented at length in the ABAG report on the Series 3 Projections.

In summary, development policies concerning industrial growth are out of balance with those related to residential growth. Industrial land reserves far exceed the projected need to 1990. Residential land reserves based on service commitments and density regulations are insufficient for the apparent need beyond 1990, assuming the highest probable regional growth trend, and insufficient in some areas even assuming the lowest probable regional growth trend.

Implications of Current Development Policy for Air Quality

In the current practice of local jurisdictions, there is little evidence land use controls are used to achieve regional air quality objectives. More stringent requirements on water and sewer services would be needed to

achieve a more compact development and consequently a reduction in auto use over the longer term. A continued pattern of low density development with long distance between home and work will continue to foster heavy dependence on the automobile. The Series 3 Projections anticipate increased work/home separation.

CANDIDATE CONTROL MEASURES[4]

Air quality improvements can be achieved in a variety of ways. As noted in the previous section, many stationary and mobile source controls have been implemented. Similarly some transportation and development controls have been instituted. A variety of additional control measures can be considered for further air quality improvements. Proposed control measures for this study were developed by the members of the AQMP-Joint Technical Staff with assistance from the AQMP-Advisory Committee.

Responsibility for developing the initial lists of control measures was delegated to the agency with the appropriate expertise. The Metropolitan Transportation Commission prepared transportation controls. The California Air Resources Board compiled mobile source emission controls. The Bay Area Air Pollution Control District inventoried stationary source controls and the Association of Bay Area Governments developed possible land use controls.

These initial "shopping lists" of measures were presented to the AQMP-Joint Technical Staff for review and comment. The complete set of control measures was reviewed at the meetings of the AQMP-Joint Technical Staff and additional input was obtained through discussion panels set up at the March 17, 1977 meeting of the AQMP-Advisory Committee.

The "shopping lists" were then screened by the agencies which had developed the initial lists to determine feasibility. This screening resulted in a shorter list of measures proposed for further analysis based primarily on technical effectiveness. If a measure was judged to have good potential for reducing pollution, it was retained despite any perceptions of high cost or implementaion difficulties.This shorter list will be used to prepare recommended strategies for the Environmental Management Task Force to consider.

The control measures and strategies have been compiled and screened on the basis of information from the literature and staff judgements concerning the most effective controls for dealing with the remaining air quality problems. At this point, the screening analysis lacks quantification and and indication of effectiveness for most measures. In the next phase of the AQMP-Joint Technical Staff work considerable effort will be devoted to assessing the emissions and air quality impact of the proposals. Details of this analysis and the procedures used to analyze alternative control startegies will be documented in a subsequent technical memorandum.

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[4] For more details see AQMP Technical Memorandum 5, "Candidate Control Measures," April, 1977.

STATIONARY SOURCE CONTROL MEASURES

An initial list of thirty-seven control options was developed by the BAAPCD ranging from new source review to tighter restrictions on existing emission sources. Many of the options were closely-related or would have such little impact on emissions that only fourteen measures appeared to be reasonably effective and recommended for additional consideration. The fourteen measures are listed below with a brief description of each:

1) Use of High Solids and Water Based Surface Coatings. This measure would reduce the amount of organic solvents used for surface coatings. It has been considered for sometime and may be a feature of the organic solvent regulation being developed by the ARB. In one form such a rule would give the control agency authority to specify industry by industry the type of coating to be employed.

2) Closed System Organic Storage. This measure would require storage of organic chemicals or fuels, probably defined by vapor pressure, to be in a closed system with vapor recovery or use as fuel. This requirement would mean conversion or replacement of existing tankage, and application to new construction.

3) Limiting Maximum SO_2 Concentration in Emissions. Current regulations permit SO_2 emissions up to a maximum of 6000 ppm where ground level monitoring indicates no SO_2 problem exist. The measure would be tightened to a 300 ppm emission limitation alone without consideration of ambient SO_2 concentrations. A limit of 300 ppm has been considered and is achievable with available technology.

4) Limit Sulfur Content of Fuel to 0.25%. This regulation would attempt to ameliorate build up of SO_2 emissions due to expected conversion from natural gas to oil or coal fuel. The current emission limitation of 300 ppm SO_2 corresponds to use of 0.5% S fuel. 0.25% sulfur fuel will be expensive and in short supply; its use has been mandated for the South Coast Basin by the ARB, effective in 1981.

5) Best Available Control Technology (BACT) on New and Existing Sources. This could be two separate measures--new and existing. For new large installations it is virtually de facto in effect. To apply this measure to existing emission sources could be very expensive. A BACT regulation could supplant many other forms of regulatory control; it is itself virtually required by some very tight emission limits. BACT has several problems--how to define BACT and how much authority to give a control agency in specifying equipment to be used among others. A BACT rule has been under study for sometime.

6) New Source Review (NSR) With or Without Off-Set. There is currently in effect a very strict BAAPCD new source review regulation as required by the EPA and ARB. The problem is not one of imposing a rule, but of modifying the rule to allow economic and industrial growth and to obtain modernization of the area's industrial facility while still reducing air pollution.

7) Change Fuel Composition Such as Lower Reid Vapor Pressure of Motor Gasoline. A lower vapor pressure would mean less evaporative emission of gasoline from storage, handling and vehicles. Side effects are less certain.

8) NOx Control for Off-Highway Construction and Agricultural Equipment. The significance of this measure is uncertain and it should probably be tied to heavy duty motor vehicle control.

9) NOx Limits for All New Boilers. Large boilers or furnaces are already subject to limitations. The BAAPCD has been studying limitations on smaller boilers but information as to reduction achievable on these smaller units is sparse.

10) & 11) The BAAPCD already imposes strict regulations on grain loading and visible emissions. Particulate emission concentration limits could be set lower and process weight allowances could be reduced but with somewhat uncertain results. Process weight regulations apply to few but large industrial plants. This might also be covered under BACT.

12) Plant Operation Scheduling. This proposal envisions scheduling operations of the areawide industrial and commercial establishment so as to level out, over the day, peaks of transportation and industrial emissions. The effect would not necessarily be to reduce overall emission of pollutants, but to level off the peaks which constitute excess of air quality standards. Implemention, however, would cause extensive changes in work and social patterns. If made voluntary it would be ineffective; if imposed it would place vast and possibly unacceptable authority in some control agency.

13) Reduce Heat and Fuel Wastage. Survey buildings and equipment for more efficient heating and air conditioning, oversized electric motors, excessive lightening, etc. Measures which conserve energy have concominant benefits for air quality.

14) Industrial Plant Modernization. Provide incentives for industry to modernize their air polltuion control facilities. Current proposals such as emissions off-set do not provide such incentives and may slow down such modernizations.

Table 2 provides a summary of relevant information on the screened list of stationary source controls. Much of the data presented are preliminary estimates which will be analyzed in more detail as the control strategies are developed.

TABLE 2 PRELIMINARY SCREENING OF STATIONARY SOURCE CONTROL MEASURES

STRATEGY	No. of Categories of Industry Affected	Contaminant	No. of Industrial Sources Affected	Source Inventory Emissions Tons/Day 1975	1985	2000	Degree of Technical Availability	Emission Reduction Achieved (T/D) 1985	2000	Degree of Impact of Reduction on Air Quality in Bay Area
1/ High Solid & Water Base Coatings	10	O	500	150	140	170	Fair	60	70	Good
2/ Closed System Organic Storage	10	O	1,000	60	70	80	Good	40	50	Fair
3/ Limit Max SO_2 to 300 ppm or Equiv. Mass	2	S	10	80	90	105	Good	40	50	Fair
4/ Fuel Conversion Requirements a) 0.25 S Max. b) Control Equip.	30 3 3 3	S P S N	1,000 40 40 60	34 10 34 32	220 20 220 306	220 29 220 252	Fair Poor Poor Poor	100 10 100 150	100 10 100 100	Excellent Negligible Excellent Fair
5/ BACT on New and Exist. Sources	100	P O N S C	10,000	117 530 268 199 412	150 570 420 410 480	165 758 406 380 578	Fair Good Poor Fair Poor	50 200 100 250 150	55 300 100 250 200	Good Excellent Fair Excellent None
6/ Continue NSR with Some Sort of Trade Off	30/YR	All	400/Year	?	?	?	Fair	?	?	Good for Interim 10 Years
7/ Change Fuel Composition, Lower Reid Vapor Pressure of Motor Vehicle Gasoline ~3 PSIA	100	O	6 Refin. 60 Bulk Plt. 6000 Ser.St. 3.5 M Veh.	105	75	80	Fair	30	35	Fair
8/ NO_x Control for Off-Highway Equipment	-	N	-	45	50	60	Fair	30	40	Low
9/ NO_x Limits for all new boilers	-	N	-	-	-	-	?			Currently under Study--- Low
10/ Lower Particulate Emission Grain Loading Limit							Fair			Low
11/ Tighten Process Weight Regulation							Poor			Low
12/ Plant Operation Scheduling	0		10,000	-	-	-	Poor	0	0	Infrequent
13/ Reduce Head And Fuel Wastage	General	N S	General	–	–	–	Fair	–	–	Low
14 Modernization of Industrial Plant	—	All	—	—	—	—	Good	—	—	Good

MOBILE SOURCE EMISSION CONTROL MEASURES

The emission control measures presented here emphasize reducing mobile emissions through better technology. The California Air Resources Board (CARB) has traditionally exercised its prerogative to adopt and enforce vehicle emission standards more stringent than those required at the federal level.

The initial list of technical control measures included four measures which are not included here. Two of these measures--promoting the use of new or modified fuel and promoting the use of alternative power sources--were excluded because the AQMP-Joint Technical Staff felt that these two measures would come about as a result of more stringent emission standards and were, therefore, repetitive. The other two--more stringent certification of compliance procedures and a more comprehensive new and used vehicle surveillance program--were combined with the inspection maintenance program. The reduced listing of five broad areas of control programs is presented below.

1) <u>More Stringent Exhaust Emission Controls</u>.* Carbon monoxide (CO), oxides of nitrogen (NO_x), hydrocarbons (HC), lead, particulate matter and some sulfur compounds are emitted from automobile engine combustion processes and are expelled into the atmosphere through the exhaust pipe.

The Clean Air Act Amendments of 1970 set as an ultimate goal for light duty vehicles (LDV) reduction of HC emissions by 95%, CO emissions by 96% and NO_x emissions by 89% by 1977. These standards have been delayed already and will most likely be delayed further by Congress. This measure would provide AQMP support for the CARB adoption of exhaust emission standards which reflect the lowest emission levels technically and economically feasible.

Current CARB standards promulgated for 1980 LDV will reduce emissions by 95% for HC, 89% for CO and 72% for NO_x over uncontrolled vehicles. As further reductions from LDV's become limited, additional controls on medium duty vehcles (MDV), heavy duty vehicles (HDV), and motorcycles may become more important and cost-effective.

2) <u>More Stringent Evaporative Emission Controls</u>. Evaporative emissions from the fuel system result from daily ambient atmospheric temperature variations and higher fuel temperature after vehicle usage. The CARB has recently adopted an evaporative emission standard of 2 grams per test for 1980 and subsequent model year vehicles. It has been estimated that this standard will reduce the total motor vehicle hydrocarbons by 36% and the HC emissions from all sources by 10% in the South Coast Air Basin by 1990. This measure would recommend that a more stringent standard be adopted and that it be applied to other mobile sources.

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*Advances in automotive technology to produce the "clean car" (e.g. electric engine) are included in this measure. The rationale for such a categorization is that sufficiently stringent standards can induce technological break throughs to meet the regulatory requirements.

3) Establishment of a Retrofit Program. This measure would require the addition of a new item, or the modification or removal of an existing item of equipment on a vehicle to reduce emissions after its initial manufacture.

Retrofit programs become less effective as old pre-controlled vehicles are replaced with vehicles meeting the more stringent emission standards. Thus, this would be considered a short-term measure which would have to be implemented as soon as possible.

An evaporative emissions retrofit program for all vehicles could be most effective in reducing HC emissions since the 2 gm/test standard will not be promulgated until 1980. A catalytic exhaust-treatment device required for post 1971 vehicles able to operate on unleaded gasoline may also be effective if it can be implemented in the near future.

4) Emission Standards for Other Mobile Sources. This measure would promote the adoption of emission standards for mobile vehicles such as agricultural tractors, construction equipment, ships entering the Bay, locomotives, recreational vehicles and miscellaneous utility engines.

As emissions from other sources are reduced through more stringent controls, the emissions from off-highway mobile sources will become increasingly more important. For example, in the 1975 BAAPCD emissions inventory these sources contributed about 4% of the organic emissions and 8% of the CO emissions. Present projections by the BAAPCD estimates that these sources will contribute approximately 6% of the organics and 22% of the CO by the year 2000. Thus, a 50% reduction in emissions from other mobile sources by 2000 will give a 3% reduction in organics and an 11% reduction in CO.

5) Motor Vehicle Inspection/Maintenance Program. This measure requires that vehicles be tested periodically to determine HC, CO and NO_x emissions. Failure to meet the prescribed emission standards would require that the vehicle be repaired and retested. Vehicles may be required to be tested on a mandatory annual basis or randomly at roadside inspection facilities and on change of ownership. This testing program would apply to new and used car dealerships as well as individual transactions to deter maladustrments being made to maximize vehicle performance. Also included here would be a more rigorous certification testing program by the CARB to reduce maintenance requirements of engine components which influence emissions or, where possible, eliminate this maintenance completely.

A pilot motor vehicle inspection program (MVIP) is currently being run in Riverside. The CARB has determined that the MVIP can provide cost-effective emission reductions. It is extimated that reductions over the total vehicle population would be about 9% for HC, 8% for CO and 0.7% for NO_x.

TRANSPORTATION CONTROL MEASURES

An initial list of transportation control measures was compiled from a review of earlier air quality plans in this area and elsewhere. The Bay Area plans that were referenced include the original Transportation Control Plan (TCP) promulgated by the EPA, the substitute TCP proposed by MTC, the Parking Management Plan (PMP), and the Transportation System Management Element (TSME).

Three broad strategies to improve air quality were identified: 1) improve traffic operations, 2) reduce automobile use, and 3) encourage alternative modes of travel. Sub-strategies were defined within these, and the actual control measures were then formulated.

The initial list of controls is summarized in Table 3. Those measures selected for more detailed analysis are shown with an asterisk (*). (For descriptions of each measure and a preliminary assessment of why the measure was dropped or retained for further analysis, see AQMP/Tech. Memo 5, "Candidate Control Measures," April 1977.)

TABLE 3. CANDIDATE AQMP TRANSPORTATION STRATEGIES

I. MEASURES TO IMPROVE TRAFFIC OPERATIONS

A. Improve Traffic Flow

1. Computerized traffic control
2. Ramp Metering *1
3. Traffic engineering improvements
4. Off-street freight loading

B. Reduce peak-period traffic volumes

1. Staggered work hours
2. Four day work week
3. Off-peak freight delivery

II. MEASURES TO REDUCE VEHICLE USE

A. Restrict Vehicle Ownership

1. Additional license fee
2. Registration limits . . . . *

B. Management of Auto Access

1. Better enforcement of parking regulations *2
2. Limit on number of parking spaces *2
3. On-street parking prohibited during peak hours . . . *2
4. Area license . . . . *
5. Auto-free zones . . . . *
6. Gas rationing . . . . *

TABLE 3 (Continued) CANDIDATE AQMP TRANSPORTATION STRATEGIES

C. Increase Cost of Auto Use

1. Road pricing
2. Increased parking costs . . . . *
3. Increased gas tax . . . . *
4. Increased tolls . . . . *
5. "Smog charges" . . . . *

D. Reduce the Need to Travel

1. Communications substitutes
2. Goods movement consolidation

III. MEASURES TO ENCOURAGE ALTERNATIVE MODES OF TRAVEL

A. Increase Transit Ridership

1. Additional transit service . . . . *
2. Fare reductions . . . . *
3. Improved comfort
4. Bus and carpool lanes . . . . *

B. Encourage Pedestrian Mode . . . . *

C. Encourage Bicycle Mode . . . . *

D. Encourage Ride Sharing . . . . *

1. Toll reduction and carpools . . . . *
2. Preferential parking and carpools . . . . *
3. Carpool matching information . . . . *

E. Promote Para-Transit Alternatives . . . . *

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* Selected for further study and analysis
*1 Combined with Bus/Carpool lanes
*2 Combined into overall parking strategy

LAND DEVELOPMENT ALTERNATIVES

For consideration in the AQMP, four land use alternatives are being analyzed. These are:

Base Cases--(Current Policy/Trend)

The current trend is a continuation of south bay suburban low density development and long home-to-work distances. In the short term this alternative accommodates development up to the service capacity limits of local jurisdictions. Projections indicate that developable land would run out by 1990, given current density policies.

Compact Development (Air Quality "Best Case")

A compact development alternative emphasizes reduced auto dependency. In the ten year short term this means that local governments would seek a more compact, higher density land use pattern, with strict controls to delay or totally bar development in the most critical air quality locations. Beyond ten years very stringent control of suburban "sprawl"--with higher densities in transit corridors and incentives for "infill" development and redevelopment--would be necessary. Measures to reduce housing/work imbalances would be included in some jurisdictions in the short term period, and for the region in the longer term.

Combinations of Above

After evaluation of the above alternatives, the best aspects of each may be combined into a third alternative. For example, the most achievable aspects of the compact development alternative might be combined with the least objectionable aspects of current trends to structure another--possibly more acceptable and achievable--alternative.

No Growth

There is theoretical alternative assuming no additional urban development. An assumption of no additional development would allow for an examination of the effectiveness of technological controls alone to meet air quality standards.

Within each land development alternative there are five factors which determine the nature of development. They are: the quantity of development expected, the location of development, the type, density, and timing or when development would occur. These factors will be adjusted to best reflect the land development alternative to be tested. For example, to measure the compact development alternative quantity would be changed to show more development occuring in already urbanized areas.

Information on local policies provided to ABAG through the Series 3 work enables us to discuss the importance these factors are given by local governments.

Timing of development is currently reflected in only a very few local development policies. It may become the most important aspect in choosing land development alternatives in that it deals with when the air quality standards will be met.

Quantity of development is currently reflected in a few local development policies. Those having the most effect are keyed to the capacity of existing and committed sewer systems. Water supply is now being used to constrain the amount and location of development by limiting the number of "hook-ups" possible. Quantitative controls will be examined for their potential role in meeting air quality objectives.

Location of development is currently dealt with most effectively at the county level by the Local Agency Formation Commissions (LAFCOs). The current trend in the region continues to focus development southward. Other alternatives in regional development will be examined. Another locational option to be considered, for example, is emphasizing development in areas already built-up to a certain extent. This could be accomplished through higher densities, conversion of existing structures, and building on vacant land.

Density of development is primarily a local concern. The current regionwide aggregate of local policy would produce much lower densities than have occurred historically. Policies relying on higher densities to meet air quality objectives would promote more use of public transit and less dependence on auto usage.

Type of development is primarily a local prerogative controlled through zoning. Many cities have more land zoned for industry than housing because they want maximum tax revenues and lower service costs. This imbalance between the amount of land for industry and housing causes longer commuting distances. The fact that commuting trips are getting longer is a major finding in ABAG's Series 3 work.

The Series 3 projections make no assumptions about regional policies. Those factors given the least current attention at local level--quantity and timing of development--may be the most important land use alternatives to be considered in the air quality plan. Alternatives are discussed below.

SUMMARY OF CANDIDATE CONTROL MEASURES

Table 4 presents a summary of control measures currently being analyzed by the AQMP-Joint Technical Staff for alternative air quality strategies. In the coming months, it is anticipated that considerable information will be developed on control strategy effectiveness, costs, and impacts.

STATIONARY SOURCE MEASURES

- High solid & Water Base Coatings
- Closed System Organic Storage
- Limit Max SO_2 to 300 ppm or equivalent mass
- Limit S content of fuel to 0.25%
- BACT on new and existing sources
- Continue NSR with some sort of trade off
- Lower reid vapor pressure of motor vehicle gasoline 3 PSIA
- NO_x control for off-highway equipment
- NO_x limits for all new **boilers**
- Lower particulate emission grain loading limit
- Tighten process weight regulation
- Plant operation scheduling
- **Reduce Heat and Fuel Wastage**
- **Industrial Plant Modernization**

MOBILE SOURCE EMISSION MEASURES

- More stringent exhaust emission controls
- More stringent evaporative emission controls
- Retrofit programs
- Emission standards for other mobile sources
- Motor vehicle inspection/maintenance program

TRANSPORTATION CONTROL MEASURES

<u>Improve Traffic Flow</u>

- Ramp metering

<u>Management of Auto Access</u>

- Parking regulations
- Limit parking spaces
- No peak hour street parking
- Area license
- Auto-free zones
- Gas rationing

<u>Increase Cost of Auto Use</u>

- Increased parking costs
- Increased gas tax
- Increased tolls
- "Smog changes"

<u>Increase Transit Ridership</u>

- Additional transit service
- Fare reductions
- Bus and carpool lanes

<u>Encourage Pedestrian Mode</u>

<u>Encourage Bicycle Mode</u>

<u>Encourage Ride Sharing</u>

- Toll reduction for carpools
- Preferential parking for carpools
- Carpool matching information

<u>Promote Para-Transit Alternatives</u>

LAND USE/DEVELOPMENT CONTROL MEASURES

More effective management of all five major aspects of land development through coordinated action by cities, counties, special districts, or regional and State agencies to reduce the magnitude and frequency of auto travel:

- <u>Timing</u> - expand the presently very limited application of timing controls such as growth sequence zoning, building permit quotas, staging of sewer and water intra-structure and plant capacities, etc.
- <u>Quantity</u> - expand the presently scattered application of quantitative controls on development such as performance standard zoning and limited sewer and water infra-structure and plant capacities.
- <u>Location</u> - Improve the presently inconsistent application of controls on the location of development such as coordinated management of infrastructure location, annexations, public land acquisition, agricultural preserves, hillside and soil conservation, and development moratoria.
- <u>Density</u> - Encourage transit usage and other non-auto modes with coordinated density policies among local jurisdictions through the application of innovative density zoning mechanisms (slope density, building height regulations, etc.) fully coordinated with service capacities and committments.
- <u>Type</u> -Reduce home-to-work & home-to-non-work travel by encouraging more land use mix, especially in terms of housing/jobs balance.

AIR QUALITY STRATEGIES

Figure I identifies four basic air quality strategies. These strategies are meant to address the photochemical oxidant problem. It should be noted that strategies for dealing with sulfur dioxide (SO_2) or particulate problems would be quite different. In considering these strategies now it cannot be assumed that one is more effective or can be more quickly carried out than another.

The air quality strategies suggested in Figure I can produce many combinations of control measures. For each strategy three sets of control measures are outlined. The controls in each set (A, B, and C) represent different degrees of "stringency". Set C is the most stringent set.

- Lifestyle Change - A strategy emphasizing transportation controls and land use or development controls. This strategy would have the most direct effect among individuals living in the region.
- Energy Conservation - A strategy to conserve energy and improve air quality. Since President Carter's energy program emphasizes conservation (as opposed to emphasizing discovery of new energy supplies), it again is comprised mostly of transportation and land use control.
- Everybody Pays - A strategy which contains measures from all major control categories. Implementation is shared by public and private sector and all governmental levels.
- Technology Dependence - A strategy which relies on improved or new technologies. This strategy affects the private sector most directly and assumes hardware approaches ("widgets") will be effective.

FIGURE 1 AIR QUALITY STRATEGIES

INCREASING COST, TECHNICAL EFFECTIVENESS & BENEFITS →

INCREASING LIFESTYLE CHANGE ↑ / INCREASING TECHNOLOGY DEPENDENCE ↓

BASIC STRATEGY	SET OF CONTROL MEASURES / STRATEGIES		
	A	B	C
1. LIFESTYLE CHANGE	INCREASED TOLLS ENCOURAGE BICYCLES, CARPOOLS MINIMUM REGIONAL INTERVENTION - ENCOURAGE INFILL, CONVERSION. - FEDERAL FUNDS FOR WATER, SEWER & ROADS.	ALL OF A PLUS: ADDITIONAL TRANSIT BUS / CARPOOL LANES RAMP METERING PARA-TRANSIT GAS TAX - 10¢/GAL. REGIONAL INTERV. ON DENSITY ENCOURAGE COMPACT DEVELOP.	ALL OF B PLUS: GAS TAX - $1.00/GAL. LIMIT PARKING SUPPLY INCREASE PARKING COSTS REGIONAL INTERVENTION ON TYPE OR MIX OF LAND USE MORATORIA OR BANS.
2. ENERGY CONSERVATION	ENCOURAGE PEDESTRIAN & BICYCLES & CARPOOLS INCREASE TRANSIT SERVICE HIGH SOLIDS/WATER BASED COATINGS CLOSED SYSTEM ORGANIC STORAGE	ALL OF A PLUS: INCREASED GAS TAX - 50¢/GAL. PARA-TRANSIT BUS/CARPOOL LANES PLANT OPERATIONS & SCHEDULES	ALL OF B PLUS: 40% REDUCTION (OR RATIONING) OF INDUSTRIAL, RESIDENTIAL & MOBILE SOURCE FUEL USE.
3. "EVERYBODY PAYS"	ALL OF 2A PLUS: NSR W/ "TRADE-OFF" I/M	ALL OF A, 2B PLUS: BACT ON NEW & EXISTING SOURCES TIGHTER MOTOR VEHICLE EMISSION STANDARDS MINIMUM REGIONAL INTERV. -ENC. INFILL, CONVERSION	ALL OF B PLUS: CLOSED SYSTEM ORGANIC STORAGE MORE STRINGENT EVAPORATIVE CONTROLS ENCOURAGE COMPACT DEVEL. REGIONAL INTERV.-DENSITY
4. TECHNOLOGY DEPENDENCE	HIGH SOLIDS/WATER BASED COATINGS CLOSED SYSTEM ORGANIC STORAGE NSR W/ "TRADE-OFF" I/M	ALL OF A PLUS: BACT NEW & EXISTING EMISSION STDS. FOR OTHER MOTOR VEHICLES MORE STRINGENT EVAPORATIVE CONTROLS	ALL OF B PLUS: NO_x FOR OFF-HIGHWAY VEHICLES & EQUIPMENT & ALL NEW BOILERS. EVAPORATIVE AND CATALYST RETRO-FIT FOR LIGHT-DUTY VEHICLES
	A	B	C

FINAL PRODUCT

The previous sections have described alternative air quality strategies being considered in the AQMP . As the strategies are being analyzed, two critical questions need to be answered:

1) What will be effective, and by when?

2) What will be implementable, and when?

The first question is a technical one which the AQMP-Joint Technical Staff will address; the second question is a political one to be negotiated with those responsible for implementation. The two questions are very much related, however, since recent air quality plans have been characterized by the inability to implement technically effective programs.

What Will Be Effective, and By When?

All of the alternative air quality strategies will improve air quality--some modestly and others quite significantly. While estimates are being made on the magnitude of the controls needed to achieve the standards, some general characteristics of the program are predictable:

- There are no "easy solutions" to the air quality problems in the Bay Area. It is too simplistic to view the problem as being readily solved by improved technology alone <u>or</u> by transportation and land use controls.

- Future control programs will cost more and are likely to be less effective than existing programs. This is because the remaining sources contribute smaller amounts of emissions but are more numerous and scattered throughout the region. Secondly, more stringent controls on existing sources may require replacing current equipment, still useable, for more expensive, slightly more effective equipment.

- Any strategy which is politically acceptable to the region must in the end face the stern test of being sufficiently effective to meet standards in a reasonable period of time.

What Will Be Implementable, and By When?

An air quality strategy that effectively deals with the problem will be difficult to implement. Here are some reasons.

<u>Stationary Source Emission Controls</u> - Additional stationary source controls are likely to be expensive and less effective than previous control efforts. In many ways it is easier to clean up the first 80 percent of the problem than the last 20 percent. There may also be a lack of available technology or reluctance to implement new or unproven technology.

Mobile Source Emission Controls - Mobile sources present similar problems to stationary source control: 1) The technologies for tighter controls are not available or have deleterious side effects (e.g. waste energy); 2) the new technologies will cost consumers a lot and require lead time, effort, and money to implement; and 3) the new technologies are unproven and are relatively expensive for the air quality benefits received, if any.

Transportation Controls - The implementation obstacles facing transportation controls are financial and institutional. Public acceptance, especially to disincentive programs, also poses many questions. Past experience has demonstrated great difficulty in securing widespread agreements on such things as carpools, ramp meters, transit improvements, increased gas taxes and tolls. At the same time AC, BART, and Muni are facing large financial difficulties.

Land Use/Development Controls - Land use/development controls have traditionally been the prerogative of local governments. The major obstacles to affecting land use changes are institutional--gaining sufficient cooperation and consensus among local jurisdictions as to what represents "optimal" or desirable regional settlement patterns from the environmental point of view. At issue, as the land use alternatives are described, is the extent of additional land management required to assure improved air quality in the Bay Area.

From this point on many programs to manage small, but collectively significant, sources of pollution will be required. This poses a very difficult implementation problem. A corner dry cleaning store using a small amount of solvent may find it difficult financially to purchase control equipment. Control measures of this type (as well as reduced auto travel) can be instrumental to the AQMP.

In summary, a comprehensive strategy which includes stationary source, mobile source, transportation control, and land use control needs to be considered. A strategy which relies on technological innovation alone is likely to be unacceptable to State and Federal agencies; it also is risky since such a strategy presumes certain technological advances will actually occur. Similarly, a strategy dependent on land use and transportation controls alone is likely to be unacceptable to the public and to local governments. It is also risky since it presumes regional development patterns can be significantly changed and the public at large will make lifestyle changes related to housing, jobs, and transportation. The comprehensive strategy, therefore, represents a "middle-or-the-road" approach which affects everyone to some degree and requires implementation of control measures by all levels of government.

PROGRESS AND SCHEDULE

Significant progress has been made in the AQMP over the past few months. Nevertheless, some minor problems continue to exist and may result in some delays in completing the draft AQMP as recently scheduled. A summary of major activities and anticipated problems is given below:

Major AQMP Activity	Status/Anticipated Problems
1) Modeling System - Land Use (ABAG); Transportation (MTC) Air Quality (BAAPCD)	1) Minor delays have been encountered due primarily to legitimate technical difficulties in obtaining necessary modeling results; also time required for interagency coordination has been underestimated.
2) Developing Alternative Air Quality Strategies	2) Generally defined; considerable effort is still needed to specify the alternatives in more detail.
3) Impact Assessment of Alternative Strategies	3) Some delays occurring since the strategies have yet to be specified in the detail needed for detailed impact assessment.
4) Plan Approval Process	4) The request to CARB for further specification of the AQMP plan approval process has yet to be received. If a comprehensive strategy is ultimately recommended, involvement of CARB and EPA at the earliest time will be necessary.

With respect to the overall AQMP planning process, the Joint Technical Staff, Interagency Management Committee and the Advisory Committee all continue to meet regularly and operate as intended. Work intensity will continue to pick up in the latter parts of the program and will lead to draft plan completion sometime this fall.

TABLE 5

SUMMARY OF AQMP ADVISORY COMMITTEE COMMENTS

COMMENT	RESPONSE
The control strategies listed in the last column of Figure 1 ("Air Quality Strategies") are not sufficiently stringent. While this column is supposed to represent the most stringent controls, the listed strategies (e.g. 10% reduction in fuel useage) are not likely to satisfy standards.	Staff has made appropriate modifications to the Figure making the strategies in column C more stringent. It should be noted that the Figure is merely an example of how the strategies would be formulated.
The stationary source measure of limiting maximum SO_2 concentrations to 300 ppm (from 6000 ppm) is misleading to those who are unfamiliar with existing BAAPCD regulations. It appears to be a significant reduction while in fact many SO_2 sources presently emit at concentrations closer to 300 ppm.	The description of this tactic has been expanded and modified to clarify this point.
The central measures of requiring high solids and water-based surface coatings and closed system storage are presently being evaluated by the California Air Resources Board.	Staff is continuing to monitor the efforts of the CARB in these areas.
Candidate control measures do not appear to have been selected on a consistent basis. Area-wide land-use control has not been specified because of major institutional problems while gas-rationing, an equally difficult to implement measure, is being considered.	Areawide land-use control is being considered as an alternative tactic, although staff has elected to use the term, "regional intervention" to encompass a broader range of actions which could be taken at a state or regional level. Areawide land-use control has not been omitted from the list of alternative control measures.

(Table 5 continued)

COMMENT	RESPONSE
The control measure of requiring best available control technology on new and existing sources needs to be defined further. What control technologies are being assumed in future emissions projections and are these considered to be the best avaliable. It is difficult for industry representatives to comment on control measures as presently stated; significantly more specification is needed.	A survey has been developed and is being implemented to study future control technologies for motor vehicle, organic solvent and combustion emissions. There are problems in predicting future technologies but efforts are being made to specify best available control technology by both the California Air Resources Board and the BAAPCD.
Control measures which would call for radical changes in the existing institutional framework and lifestyle are grouped under the first theme entitled "lifestyle change". However, there are some effective transportation controls which do not have as severe an impact and are relatively easier to implement e.g. toll increases. These might better be considered separately from the more radical measures.	Regardless of the relative severity of controls, they have been grouped according to the control approach--namely, achieving emission reductions through changes in emission control technology or through changes in people's activities. If there is some stigma attached to the phrase "lifestyle change", the phrase should be changed rather than creating a separate theme for less severe control measures.
The chart of air quality strategies does not include an indication of the flexibility or reversibility of the strategies. This is an important criterion for selection of the strategy to be implemented.	Agreed, the chart was not intended to include all of the assessment criteria to be used in evaluating plan alternatives. A separate assessment task will address this criterion as well as many others.

SUMMARY OF ENVIRONMENTAL MANAGEMENT TASK FORCE COMMENTS

COMMENT	RESPONSE
Stationary Source Control Measures:	
In addition to the concentration limits listed for sulfur dioxide control, the Bay Area APCD advisory committee is also assessing a total quantity limit for sulfur compound emissions as an alternative approach. This should be added to the list of measures to be studied.	This measure is listed as an alternative to the concentration limit approach, and is referred to as "equivalent mass."
The control measures listed for sulfur emissions should not be expressed in detail at this time, since evaluation may suggest that different limits may be more advantageous. Being specific on these measures at this time is inconsistent with the more generalized nature of the other measures on the list.	The 300 ppm and 0.25% S limitations are quoted as examples of limits already in force in some pollution control regulations. Stricter or less strict limits as can be justified may be adopted for AQMP.
The trade-off or offset option for new source review should be broadly interpreted to inlcude tradeoff between stationary source and motor vehicle emissions resulting from a given project --e.g., if an industry were to locate in an area where the vehicle miles travelled by its employees/patrons would be minimized, credit should be given when evaluating the new source permit application for the facility.	Various forms of emissions offset are currently being evaluated. However, offsets between motor vehicle emissions and stationary emissions are not being considered for three primary reasons: 1) Forecasts of VMT reductions are much more uncertain than forecasts of stationary emissions; 2) there is no identifiable means of quaranteeing the continuance of the emission reductions obtained and 3) the administrative difficulties associated with such a rule are significantly greater than with other forms of offset.

SUMMARY OF ENVIRONMENTAL MANAGEMENT TASK FORCE COMMENTS

COMMENT	RESPONSE
Transportation Control Measures:	
A measure to improve comfort and safety in transit systems as an incentive to use public transit should be included.	This measure was considered in initial efforts. It was found that many transit districts have on-going programs to improve comfort and safety, such that any additional impetus from an air quality standpoint would not be significant.
It is important to recognize that many of the control measures listed (particularly the transportation controls) should not be implemented uniformly across the region. The significant differences between various parts of the region in terms of the transportation system suggest that controls should be made more area-specific.	Staff recognizes this important caveat and agrees with the comment. Certain measures such as carpooling incentives can be approached at a regional level, while others such as freeway ramp metering are best considered on a segment-by-segment basis.
The Metropolitan Transportation Commission is currently required to assess the consistency of the Regional Transportation Plan with the State Air Quality Implementation Plan. This should be included on the list of control measures.	The requirement for a consistency assessment exists now and is considered part of existing control programs rather than an alternative for future consideration. Moreover, it is an enforcement tool rather than a control measure.
Other:	
The control measure which uses urban infrastructure (water, sewer, roads) to control land use should be rephrased. Infrastructures should be used to serve local and/or regional land use plans which incorporate air quality objectives.	It is possible, though not necessarily desirable, to use infrastructure as a form of short term land use control. In the long term, the more logical and desirable form would be to have infrastructure facilities serve land use plans as stated in the comment.
The names of the strategies ought to be changed since some of the terms used carry unnecessarily negative connotations.	The names of the strategies will be modified to more appropriately reflect their respective objectives.

ENVIRONMENTAL MANAGEMENT PROGRAM

AIR QUALITY MAINTENANCE PLAN BRIEF NO. 3

AIR QUALITY PROBLEMS

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PREPARED FOR THE

ENVIRONMENTAL MANAGEMENT TASK FORCE

AUGUST, 1977

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INTRODUCTION

This is the third of four briefs covering the Air Quality Maintenance Plan (AQMP). It describes the air quality problems in the Bay Area--past, present and future. Previous briefs presented the AQMP goal and alternative air quality strategies. This brief concentrates on the extent of the present and future problems as projected assuming no additional control programs beyond those currently adopted. It also presents a preliminary estimate of the air pollutant emissions reduction required to achieve the program goal. The emissions reduction required prescribe the extent and magnitude of needed air quality control strategies. As in previous briefs, an updated view of the final product is also given.

ISSUE: The brief describes historic and present air quality problems. It projects future emissions trends and air quality assuming no new control programs beyond those currently adopted. An estimate of the solution required to achieve the program goal is made. A comprehensive air quality strategy approach is described for EMTF review and comments. The proposed approach builds upon existing air pollution control programs and describes the need for additional controls. It is assumed that time extensions to meet Federal and State air quality standards could be granted provided there is demonstration of:

1) Good faith efforts by State, regional, and local governments, and

2) Steady progress toward the goal.*

EMTF ACTION: Two actions are sought by the AQMP-Joint Technical Staff

1. Approve the statement of the air quality problems--extent, magnitude, and causes--as presented in the brief, and

2. Endorse a comprehensive control strategy approach for dealing with the remaining and projected air quality problems. Such an approach will require Federal, State, regional and local actions and include at a minimum, further technological controls on stationary and mobile sources and transportation and land use controls.

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*The goal of the AQMP is attainment and maintenance of Federal and State air quality standards as expeditiously as practicable.

PAST AND PRESENT AIR QUALITY[1]

The base year of 1975 is indeed a reasonably representative year, balanced between the generally clean well ventilated weather conditions of 1966 and 1972, and the dirty stagnant conditions of 1965, 1969, and 1976. Thus the 1975 data for selected contaminants have been mapped (see Figures 1-6) to show their geographic variation in the Bay Area. These maps then give perspective for brief discussions of the contaminants.

From these 1975 annual summary maps, one may see that the sulfur dioxide maximum is centered in a crescent along the Contra Costa coast, with no impact south of Burlingame. Moreover the annual averages are only 7% of the Federal standard. The total suspended particulate maximum is centered over the Livermore Valley, where the Federal standard is exceeded for 1975, and high values extend to the Santa Clara Valley, where the State standard is exceeded for 1975. For carbon monoxide, the excess "day" maximum is located over downtown San Jose, as a winter evening phenomenon. For photochemical oxidant, the excess day maximum is centered over the East Santa Clara Valley with an extension to Livermore.

Sulfur dioxide and oxidant levels have decreased significantly over the past decade. Suspended particulate has decreased, but more sporadically because of weather-related non-anthropogenic sources. Carbon monoxide has decreased overall, but increased in the Santa Clara Valley, because of increased vehicular travel in an area of very limited dispersion.

More recent air quality data for 1976 is summarized in Table 1. These data indicate a regionwide photochemical oxidant problem and numerous violations of carbon monoxide and total suspended particulate standards in certain locations of the region.

SULFUR DIOXIDE

The map of annual average sulfur dioxide values for 1975 (Figure 1) shows a relatively narrow band exceeding 3 parts per billion (ppb) centered on the shores of Contra Costa County with extensions to San Francisco Airport and into the Delta. The Federal standard for SO_2 annual average is 30 ppb, thus most of the Bay Area has less than one-tenth the SO_2 levels allowed by the Clean Air Act. The annual average for all District stations is 2.1 ppb, or 7% of the Federal Standard.

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[1]For more details, see AQMP/Tech Memo 3, "Air Quality: Past and Present," March 1977 (prepared by the Bay Area Air Pollution Control District).

The District maximum of 11.3 ppb is recorded at Crockett, near a chemical plant which manufactures and ships SO_2 as its major product. Even here the annual levels are 60% below the Federal annual standard and encompass a small largely unpopulated area. The one 1975 excess of the State one-hour standard (.5ppm, or 500 ppb) occurred at Crockett in July. However, there were numerous excesses of the District 3-minute regulation, which has a time frame 20 times more restrictive than the State standard and 60 times more restrictive than the Federal standard.

The 1975 SO_2 average is 63% lower than that for 1969 when this monitoring program began. Despite the energy-related fuel-switch problems of 1973-74, the 3-year average for 1973-75 is 39% lower than that for 1969-71, due to stringent District control of major point sources. Projected decreases in global availability of clean fuels suggest increasing difficulty in maintaining the current low levels of sulfur gases.

TOTAL SUSPENDED PARTICULATE

The annual geometric means of total suspended particulate (TSP) show a pattern of low values near the coast increasing with distance inland, particularly into dry sheltered valleys (see Figure 2). The values are given in micrograms per cubic meter ($\mu g/m^3$) which is a measure of weight. The Federal primary standard, expressed as an annual geometric mean is 75 $\mu g/m^3$ and the State standard is 60 $\mu g/m^3$. In 1975 the Santa Clara and Livermore Valley areas exceeded the State standard, and the Livermore Valley also exceeded the Federal standard.

CARBON MONOXIDE

Maps of annual average values as drawn for the previous pollutants are of little value for carbon monoxide, since over 90% of the CO is emitted from vehicular sources resulting in a complex latticed pattern corresponding closely to highway networks. These tail-pipe level emissions are also particularly sensitive to low-level radiation inversions, resulting in very strong daily and seasonal cyclic variations.

Despite the large tonnage of CO emissions, the Federal and State one-hour CO standards have not been exceeded in the current decade. However, the Federal 8-hour average standard of 9 ppm has been frequently exceeded in some areas. The accompanying CO map shows the number of days in 1975 with such excesses (see Figure 3). The major excess area is the Santa Clara Valley, centered on San Jose and extending to Sunnyvale. There is a small secondary maximum over Vallejo, and isolated urban-center cases at San Francisco, Oakland, and San Rafael. The District average CO data have shown an 11% decrease from 1970 to 1975. Measured ambient CO levels decreased less rapidly than total emission, apparently because the ambient values in this air basin are most sensitive to winter evening driving modes and patterns.

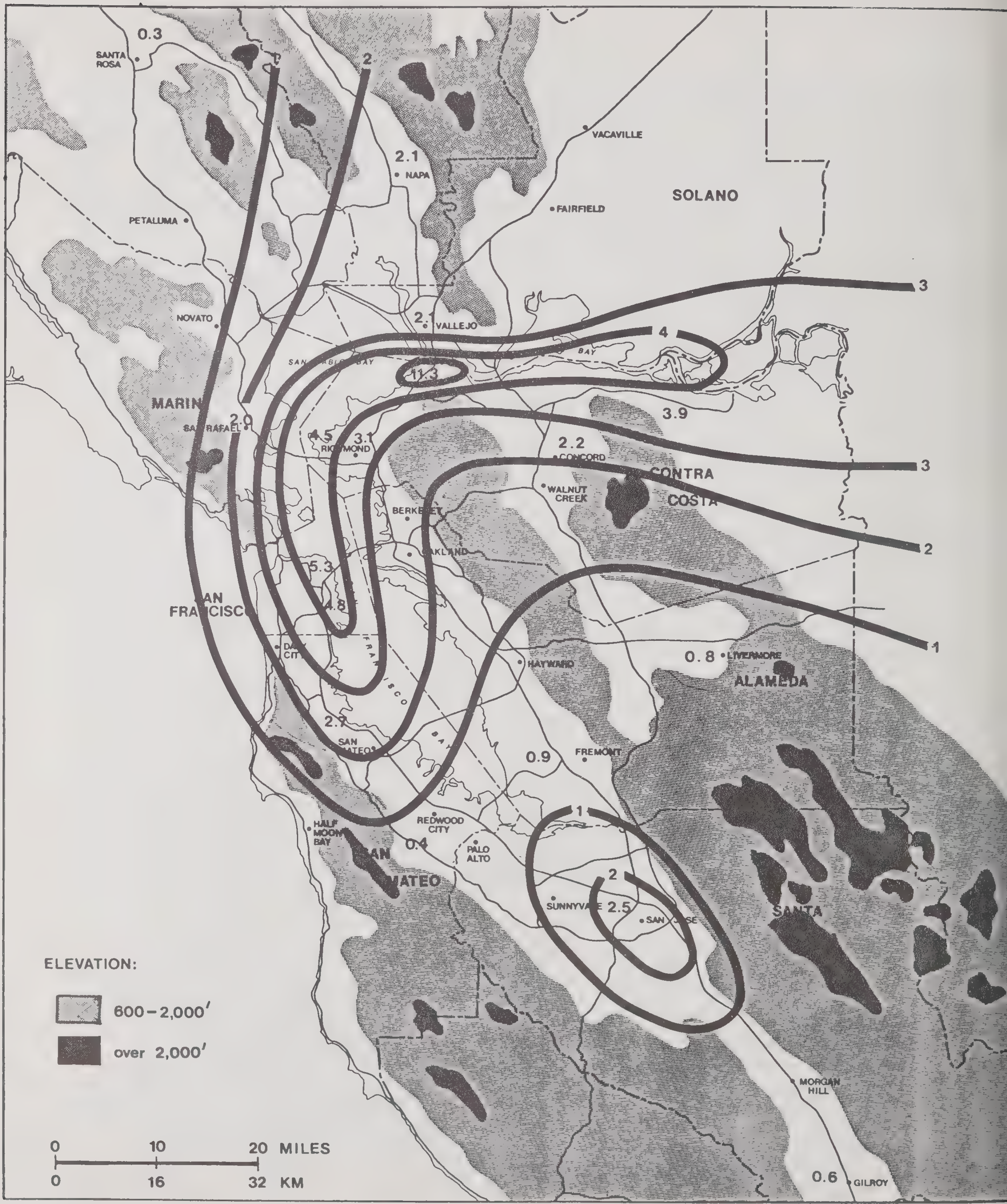
PHOTOCHEMICAL OXIDANT

Photochemical oxidant, as the contaminant of initial and deepest concern in California has now been continuously monitored for 15 years by the BAAPCD. After peaking in 1965, the oxidant levels have shown a clear downward trend for the past 11 years, despite large annual weather-induced fluctuations. Days exceeding the Federal one-hour standard of .08 ppm averaged 131 in the 1965-69 pentad and 85 in the 1970-74 pentad. For the 1975 base year there were 69 days over standard, and preliminary totals for 1976 show 65 days. Despite more than 50 % improvement over the past decade, oxidant remains the largest and most difficult problem in terms of air quality maintenance.

For oxidant the accompanying maps (Figures 4 and 5) plot the number of days over standard in 1975, and for comparison the average values in the 1970-74 period. Both maps show minimum excesses (0 to 5 days) along the coast, but in 1975 the clean band had widened and extended further inland. Maximums in both cases are over the inland sheltered valleys, but there are two significant differences. First, the 1975 intensity of the maximum is 20% lower, decreasing from 60 days to 50 days. (Preliminary 1976 data indicates a further weakening of this maximum to less than 35 days.) Second, the center of the maximum has shifted from the Livermore Valley to the East Santa Clara Valley. (Preliminary 1976 data show the center remaining as in 1975, but extending more toward Gilroy than toward Livermore.)

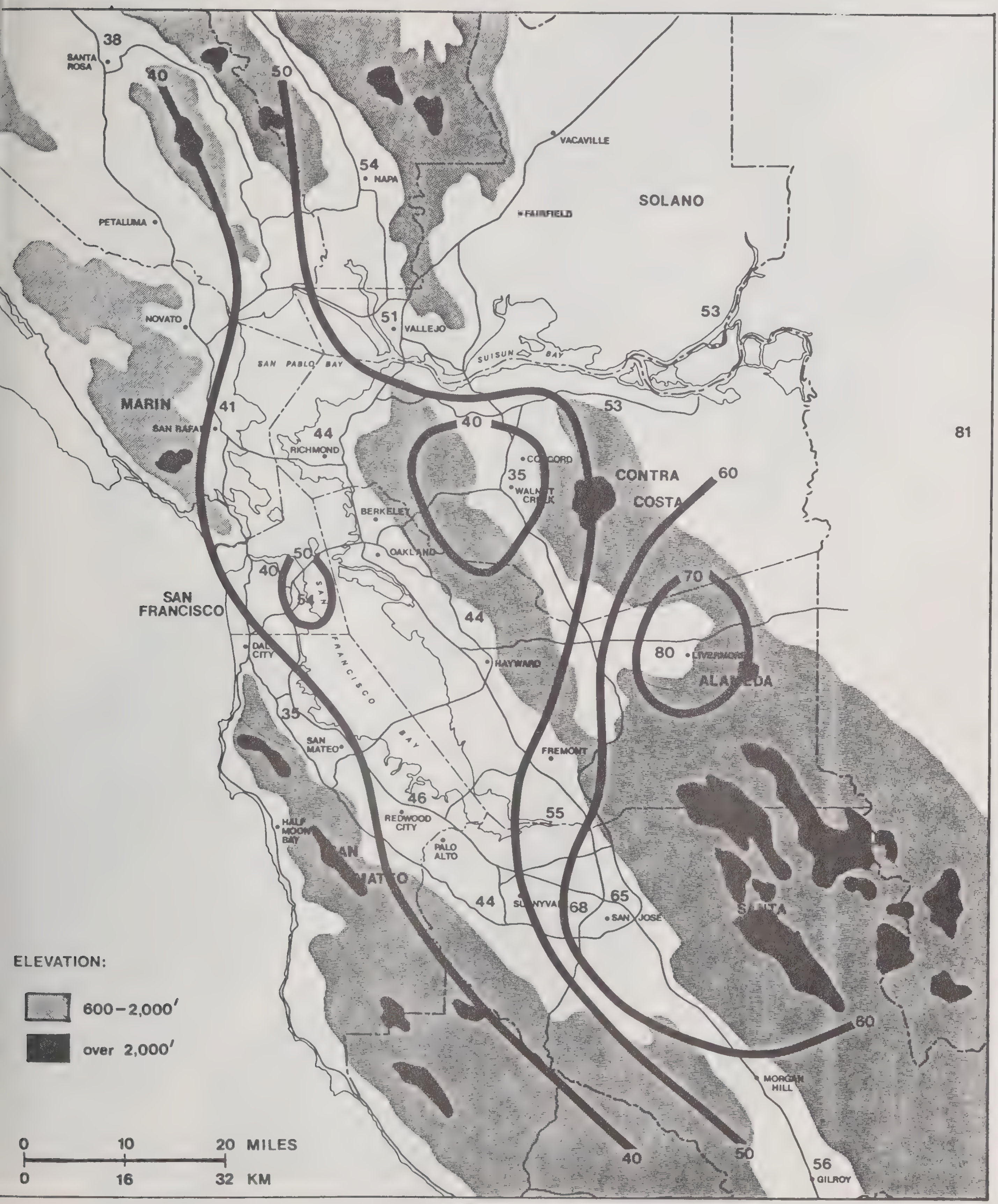
Since the formation of oxidant is highly weather-dependant, the District has developed a "trend study" technique to damp out the primary weather factors (temperature and inversion height) and compare the oxidant levels only for days when these conditions favor its formation. Results of this study (updated to include 1976) are shown in the final graph (Figure 6). On oxidant-conducive days, the District average (for our 7 long-term stations)peaked at .10 ppm in 1965 and has fallen to .06 ppm in 1976. In 1971 this average fell below the Federal standard and has remained below it ever since. The two long-term stations with averages remaining over standard are San Jose and Livermore.

The southeastward migration of highest values over the years is another noteworthy feature of the oxidant trend graph. San Leandro led (with over .14 ppm) in 1964 and 1965; Livermore led (with over .14 ppm) in 1968 and 1969; San Jose led (with .11 to .13 ppm) in 1974 and 1975. These highest station averages have fortunately decreased at nearly the same rate as the overall District average. The reasons for the shift appear quite complex--related to the 15-year shifts in population and vehicle use, and to the changes in emission mix and emission patterns. Additionally, the increases in emissions of primary contaminants have been into the sheltered valleys topographically and meteorologically least favorable for mixing and dispersion.



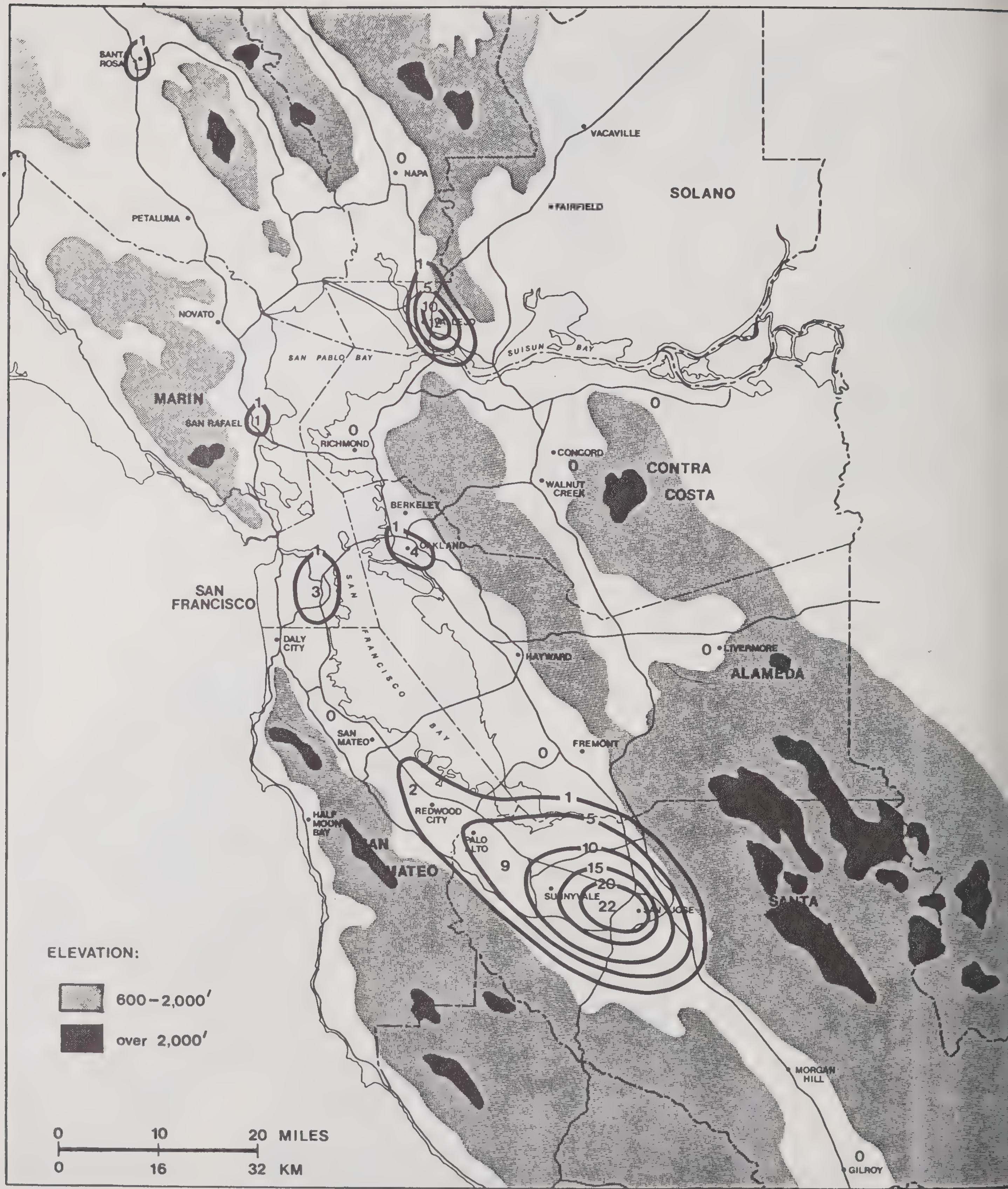
1975 Annual Average Sulfur Dioxide Values in parts per billion (ppb). Federal standard is 30 ppb.

Figure 1



1975 Annual Geometric Means of Total Suspended Particulate in $\mu g/m^3$ (by hi-volume method with fiberglass filters). Federal primary standard is 75 $\mu g/m^3$. State standard is 60 $\mu g/m^3$.

Figure 2



1975 Annual Number of Days with Carbon Monoxide Exceeding Federal Standard (9 parts per million for 8 hours).

Figure 3

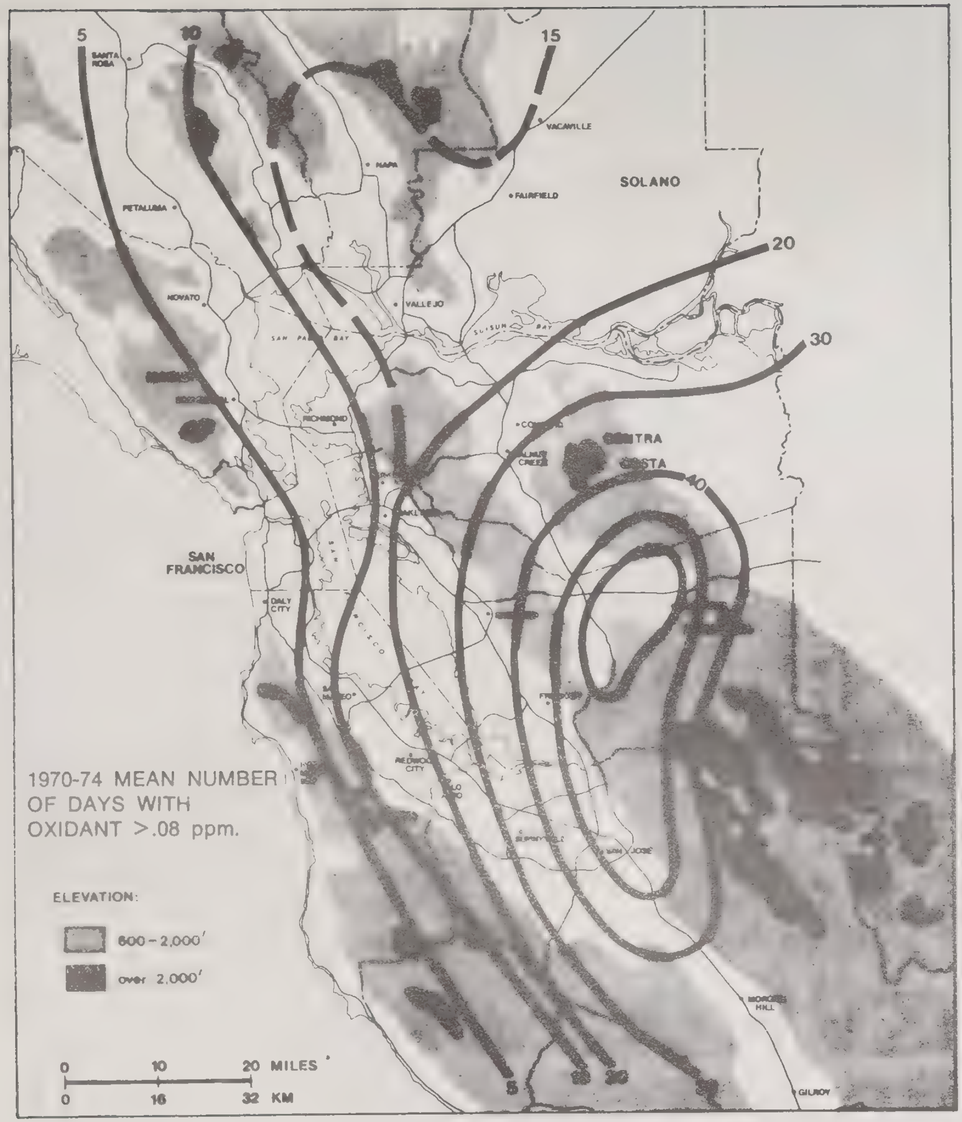


Figure 4

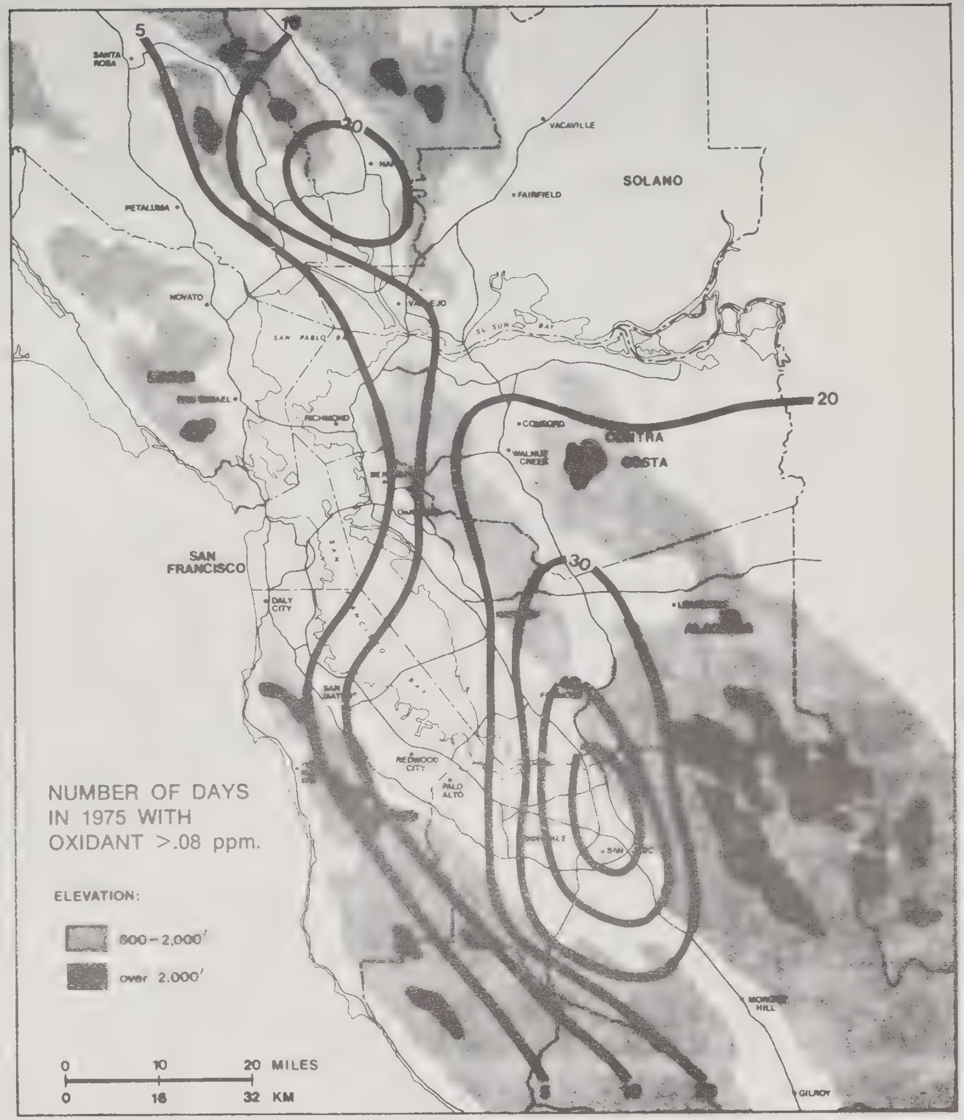
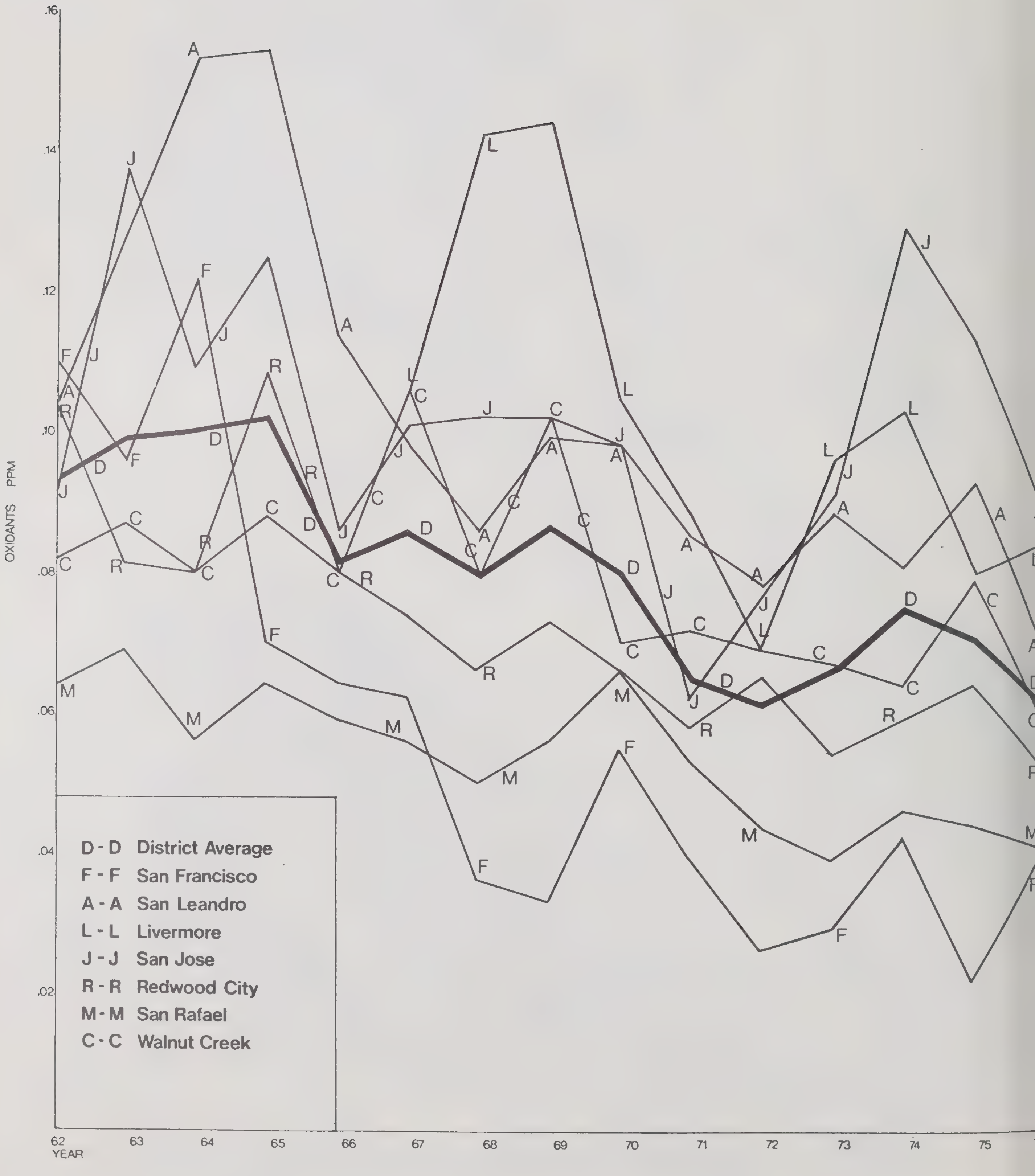


Figure 5

Figure 6



Trend of Average High-Hour Oxidant Concentrations For Days With Comparable Temperature & Inversion Conditions (April through October Photochemical Oxidant Seasons 1962-1976

ıble 1.

AIR POLLUTION IN THE BAY AREA BY STATION AND CONTAMINANT: 1976

For oxidant and for nitrogen dioxide, "max" is the highest hourly average value expressed in parts per hundred million. For rbon monoxide, "max" is highest 8-hour average value in parts per million. (The one-hour standard for CO was never exceeded ıring the year.) For sulfur dioxide, "max" is highest 24-hour average value expressed in parts per million. For total suspended ırticulates (TSP), "mean" is annual geometric mean in micrograms per cubic meter.

	OXIDANT			CO		NO_2		SO_2		TSP	
Stations	Max	*	M**	Max.	*	Max.	*	Max.	+	Mean	+
ın Francisco	13	2	*3*	11.0	4	25	1	.053	1.8	55	9.3
ın Rafael	12	5	*8*	15.5	7	13	0	.015	0.0	36	6.4
ichmond	13	7	*9*	6.8	0	23	0	.013	0.0	48	12.0
ttsburg	15	29	*22*	5.5	0	19	0	.015	0.0	61	16.0
oncord	17	24	—	7.4	0	23	0	.030	0.0	51	12.8
/alnut Creek	14	10	*28*	—	—	—	—	—	—	—	—
akland	15	6	*7*	10.5	7	—	—	—	—	—	—
an Leandro	16	9	*23*	—	—	—	—	—	—	—	—
ayward	18	30	—	—	—	—	—	—	—	—	—
remont	16	21	*39*	9.8	1	28	2	.011	0.0	62	18.1
vermore	17	29	*60*	7.1	0	18	0	.005	0.0	85	41.3
lum Rock	16	31	—	—	—	—	—	—	—	—	—
an Jose	17	32	*40*	20.2	61	28	3	.015	0.0	71	20.8
ilroy	21	30	—	6.8	0	23	0	.011	0.0	62	11.7
os Gatos	14	19	*32*	—	—	—	—	—	—	—	—
unnyvale	15	22	—	12.8	14	30	4	.008	0.0	50	8.6
ountain View	14	11	*12*	—	—	—	—	—	—	—	—
edwood City	17	16	*15*	10.2	10	21	0	.007	0.0	59	13.0
urlingame	15	3	*10*	9.5	1	22	0	.018	0.0	49	7.0
etaluma	9	5	*6*	—	—	—	—	—	—	—	—
anta Rosa	9	1	—	9.5	1	15	0	.004	0.0	66	8.6
onoma	13	21	—	—	—	—	—	—	—	—	—
apa	12	16	*16*	10.8	2	11	0	.009	0.0	65	11.8
allejo	18	21	*16*	18.0	40	14	0	.014	0.0	52	10.2
airfield	14	17	*16*	—	—	—	—	—	—	—	—
rockett	—	—	—	—	—	—	—	.026	0.0	—	—
artinez	—	—	—	—	—	—	—	.020	0.0	—	—

Number of days ambient air quality standard was exceeded. (Federal oxidant standard >8 pphm.)
** For comparison, average number of days oxidant standard was exceeded in 1970-1974 mean.
Percent of observed days when State air quality standard was exceeded.

Source: Bay Area Air Pollution Control District, 1977

PRESENT AND PROJECTED EMISSIONS[2]

This section presents a summary of present and projected emssions of five major air contaminants for the San Francisco Bay Region. The purpose of the emissions inventory is to identify each significant source of pollutants contributing to the air quality problems of the region. In some cases, it is possible to identify a single category of sources as being the major contributor to a given problem (e.g., carbon monoxide from motor vehicles or sulfur dioxide from fuel combustion in industrial and utility boilers). In other cases such as for photochemical oxidant, no single category of sources can be identified as the root of the problem. By identifying the most significant sources in each case, the emissions inventory provides direction for efforts to control emissions and minimize the problems they cause. Thus, the inventory is a crucial prerequisite to the development of any plan to improve air quality.

In order to develop a long range plan to improve air quality, it is necessary to know not only what current emission levels are, but what future emission levels will be. As described in the AQMP/Tech Memo 2 (December 1976), estimates of current emissions from each category of sources are combined with estimates of the rate of growth in each case and the expected effects of control programs which are in effect now, or adopted and scheduled for implementation. The one exception to this is the Bay Area Air Pollution Control District's New Source Reveiw rule, which is <u>not</u> included in the emission projections. This is necessary so that the effectiveness of New Source Review as well as alternative New Source Review rules can be evaluated equally with other control programs. The projected emissions thus reflect normal growth trends.

SUMMARY OF THE EMISSIONS INVENTORY

Emission inventories have been compiled for 1975, 1985, and the year 2000, and are summarized in Tables 2, 3, and 4. They are also shown in graphic form in Figure 7 through 11. Estimates of stationary source and aircraft emissions were made by the Bay Area Air Pollution Control District, while motor vehicle emissions estimates were made through the joint efforts of ABAG, MTC, and the California Air Resources Board.

For hydrocarbons, the most significant source categories are organic compounds evaporation (otherwise known as organic solvents) and both light and heavy duty motor vehicles. Each of these source categories have previously been the target of control efforts, and it is evident that further controls will be necessary if significant air quality improvement is to be made. Total hydrocarbon emissions are projected to decrease somewhat by 1985 due to the implementation of controls now on the books, but to rise back to the 1975 level by the year 2000.

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[2]For more details, see AQMP/Tech Memo 11, "Present and Projected Air Pollutant Emissions in the San Francisco Bay Region," August 1977.

For oxides of nitrogen, the principal source categories are stationary source fuel combustion, and light and heavy duty motor vehicles. Efforts to control motor vehicle NOx emissions have been controversial in recent years while stationary source NO_x control has been limited to only the largest sources. The problem in pursuing NO_x control is that NO_x alone is not a problem in the Bay Area. It is a contributor to the photochemical oxidant problem in the region, but its precise role has not been well defined to date. NO_x emissions are projected to remain at a relatively constant level over the 25 year planning time frame. By 1985, the expected increase in stationary source NO_x emissions due to increased use of fuel oil will be offset by additional motor vehicle NO_x control. By 2000, increasing usage of nuclear fuels for electric power has been assumed to offset increased NO_x emissions in other source categories.

In the case of carbon monoxide, light and heavy duty motor vehicles are by far the most significant sources. Unlike hydrocarbon and NO_x emissions, CO emissions are projected to be substantially <u>greater</u> in the year 2000 than they are in 1975. The principal causes of this result are the overall growth in vehicle activity over the 25 year period, and the expected deterioration of current vehicle emission control devices.

Sulfur dioxide emissions are due primarily to stationary source fuel combustion, and petroleum refining and chemical operations. A substantial increase in SO_2 emissions is projected to occur by 1985, due primarily to the progressively limited supplies of natural gas and the expected switch to fuel oil and coal for combustion processes. SO_2 emissions decrease slightly by the year 2000 due to an assumed switch of a portion of PG&E's electric power generating capacity to nuclear plants.

Finally, emissions of suspended particulate matter are produced from many diverse sources, with no single source or sources contributing a large share. Emissions for this pollutant are projected to increase steadily between 1975 and 2000. A significant unknown is the contributions to particulates from windblown dust and secondary organics (photochemical aerosol). Until these unknowns are better defined, it will be difficult to properly interpret the emission inventory for particulates.

TABLE 2. 1975 EMISSIONS BY MAJOR SOURCE CATEGORY

MAJOR SOURCE CATEGORY	EMISSIONS (TONS/DAY) HC	NO_x	CO	SO_2	Part.
Petroleum Refining	25.2	5.9	-	39.0	2.5
Chemical	5.5	3.1	37.3	84.6	4.9
Other Industrial/Commercial	10.2	2.5	21.7	5.9	75.3
Petroleum Refinery Evaporation	46.0	-	-	-	-
Gasoline Distribution	60.4	-	-	-	-
Other Organic Compounds Evaporation (Organic Solvents)	311.1	-	-	-	-
Combustion of Fuels	8.1	196.0	17.5	43.7	16.3
Burning of Materials	19.8	1.4	58.2	0.3	12.9
Off-Highway Mobile Sources	45.0	59.4	277.7	25.8	5.2
Aircraft	19.6	13.5	54.5	1.3	9.0
Light-duty Automobiles	340.1	231.7	2,357.0	7.4	27.8
Other Motor Vehicles	132.2	167.8	1,507.0	11.3	15.2
TOTAL (TONS/DAY)	1,023	731	4,331	219	169

TABLE 3. 1985 EMISSIONS BY MAJOR SOURCE CATEGORY

MAJOR SOURCE CATEGORY	EMISSIONS (TONS/DAY)				
	HC	NO_x	CO	SO_2	Part.
Petroleum Refining	41.0	15.2	-	67.5	4.4
Chemical	5.6	2.9	37.5	89.1	5.2
Other Industrial/Commercial	11.1	2.7	24.0	6.5	80.8
Petroleum Refinery Evaporation	50.0	-	-	-	-
Gasoline Distribution	27.1	-	-	-	-
Other Organic Compounds Evaporation (Organic Solvents)	344.8	-	-	-	-
Combustion of Fuels	11.5	321.1	21.3	213.9	34.5
Burning of Materials	22.2	1.5	62.7	0.3	13.9
Off-Highway Mobile Sources	50.3	73.7	322.6	30.9	6.3
Aircraft	20.2	19.6	69.9	1.6	11.4
Light-duty Automobiles	117	89.3	1,768.7	9.7	18.8
Other Motor Vehicles	96	165.8	1,699.3	15.0	16.3
TOTAL (TONS/DAY)	797	692	4,006	435	192

TABLE 4. 2000 EMISSIONS BY MAJOR SOURCE CATEGORY

MAJOR SOURCE CATEGORY	EMISSIONS (TONS/DAY) HC	NO_x	CO	SO_2	Part.
Petroleum Refining	55.4	20.0	-	88.9	5.8
Chemical	6.	3.9	37.5	119.8	6.1
Other Industrial/Commercial	12.7	3.1	24.0	7.4	90.5
Petroleum Refinery Evaporation	52.1	-	-	-	-
Gasoline Distribution	28.2	-	-	-	-
Other Organic Compounds Evaporation (Organic Solvents)	493.4	-	-	-	-
Combustion of Fuels	15.0	279.8	25.7	129.9	30.7
Burning of Materials	23.6	1.7	69.7	0.4	22.5
Off-Highway Mobile Sources	75.4	94.1	389.3	31.1	7.8
Aircraft	27.8	32.7	106.3	2.5	19.4
Light-duty Automobiles	160.6	77.1	2,505.0	13.2	22.3
Other Motor Vehicles	107.1	208.4	2,505.0	20.4	19.8
TOTAL (TONS/DAY)	1,058	721	5,663	414	225

FIGURE 7

HYDROCARBON EMISSION TRENDS

SAN FRANCISCO BAY REGION

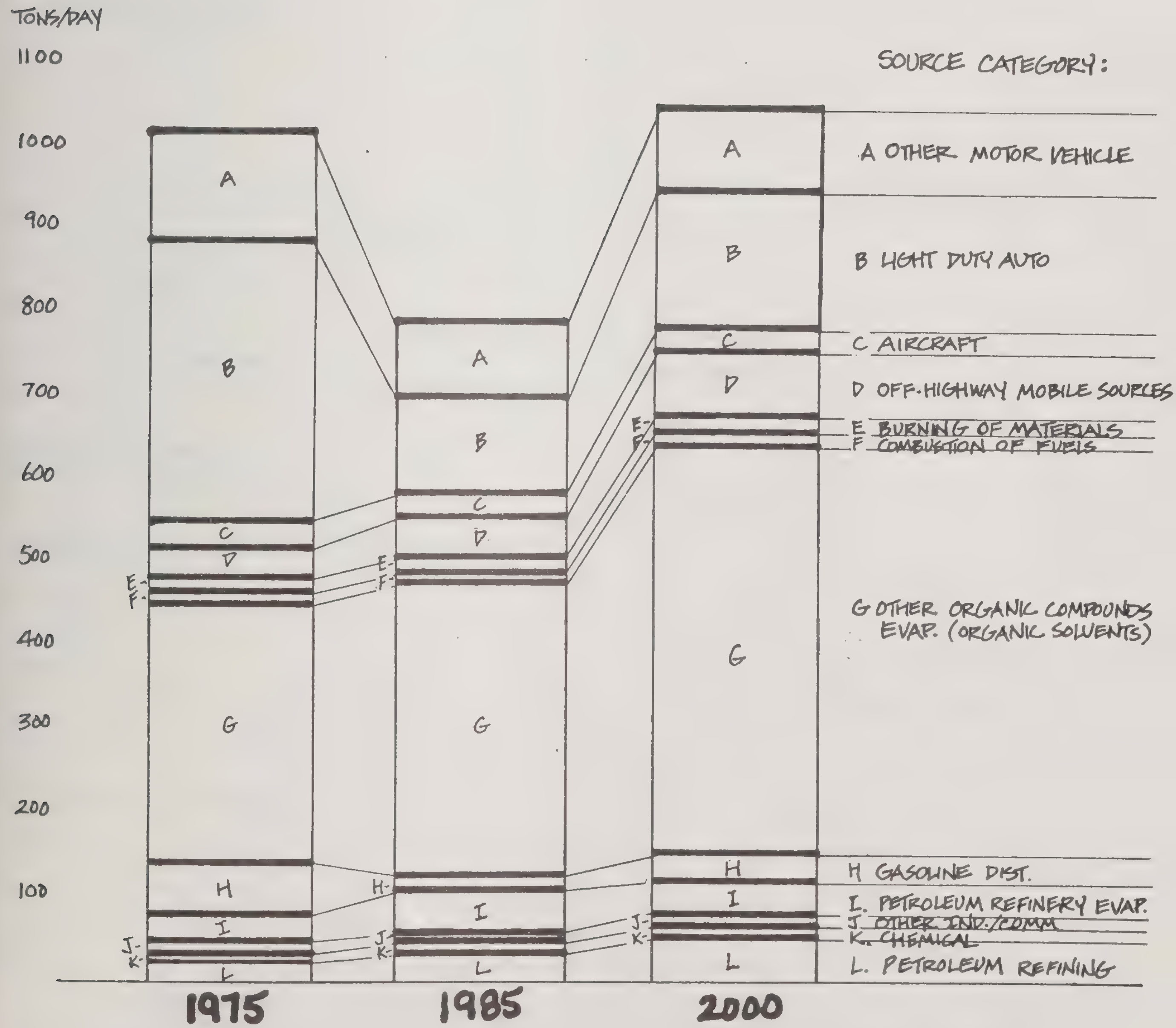


FIGURE 8

NITROGEN OXIDES EMISSION TRENDS

SAN FRANCISCO BAY REGION

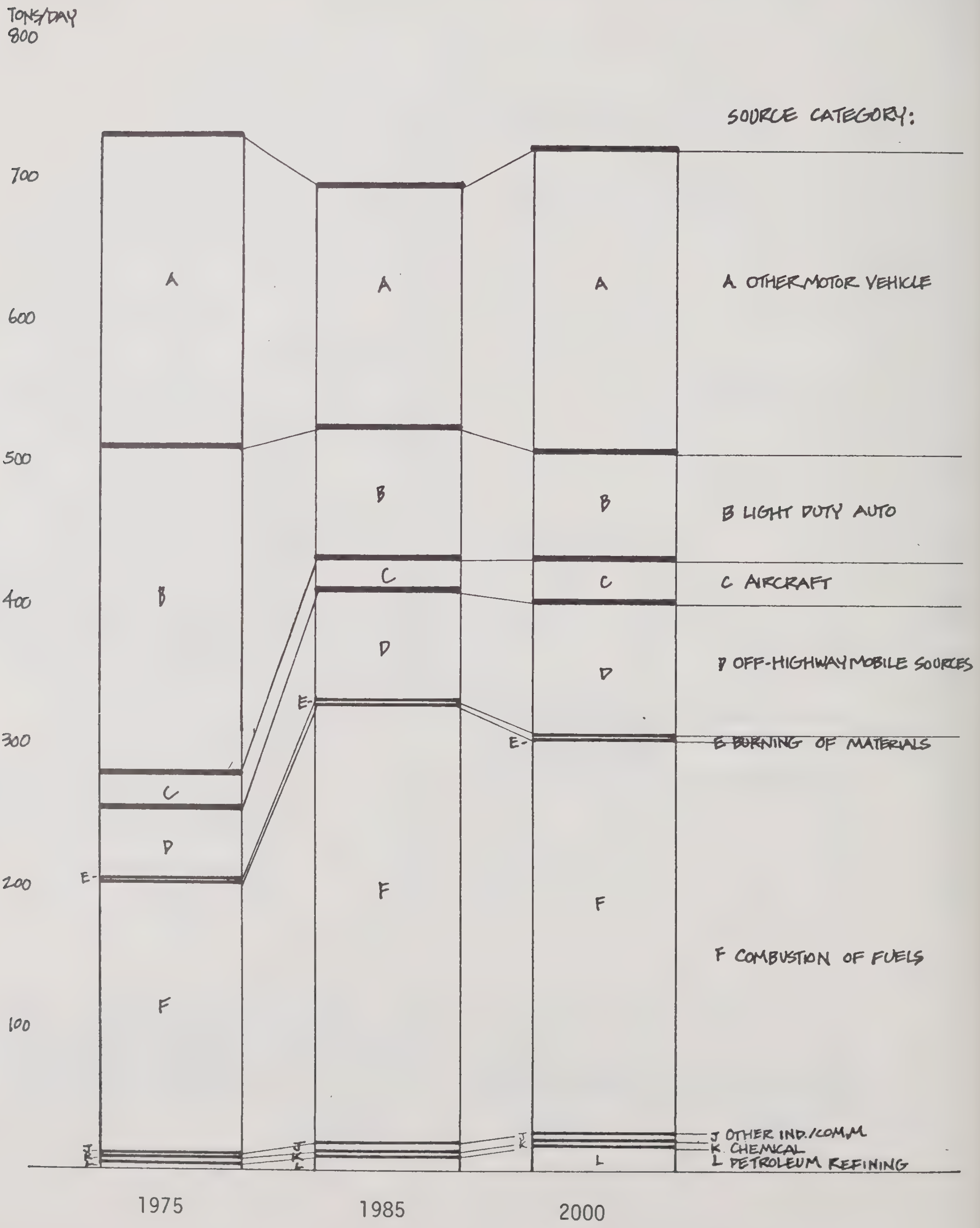


FIGURE 9

CARBON MONOXIDE (CO) EMISSION TRENDS

SAN FRANCISCO BAY REGION

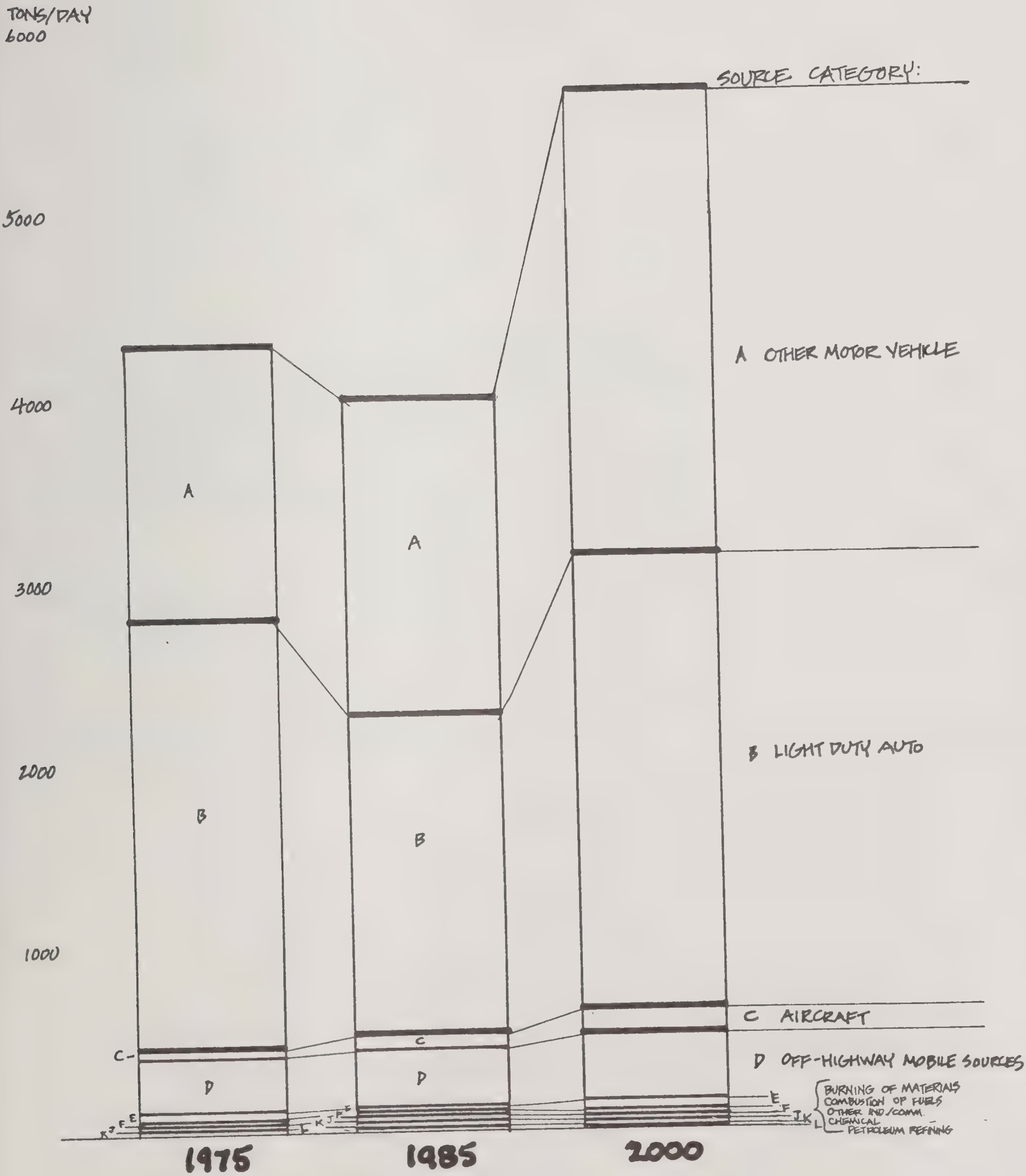


FIGURE 10

SULFUR DIOXIDE EMISSION TRENDS

SAN FRANCISCO BAY REGION

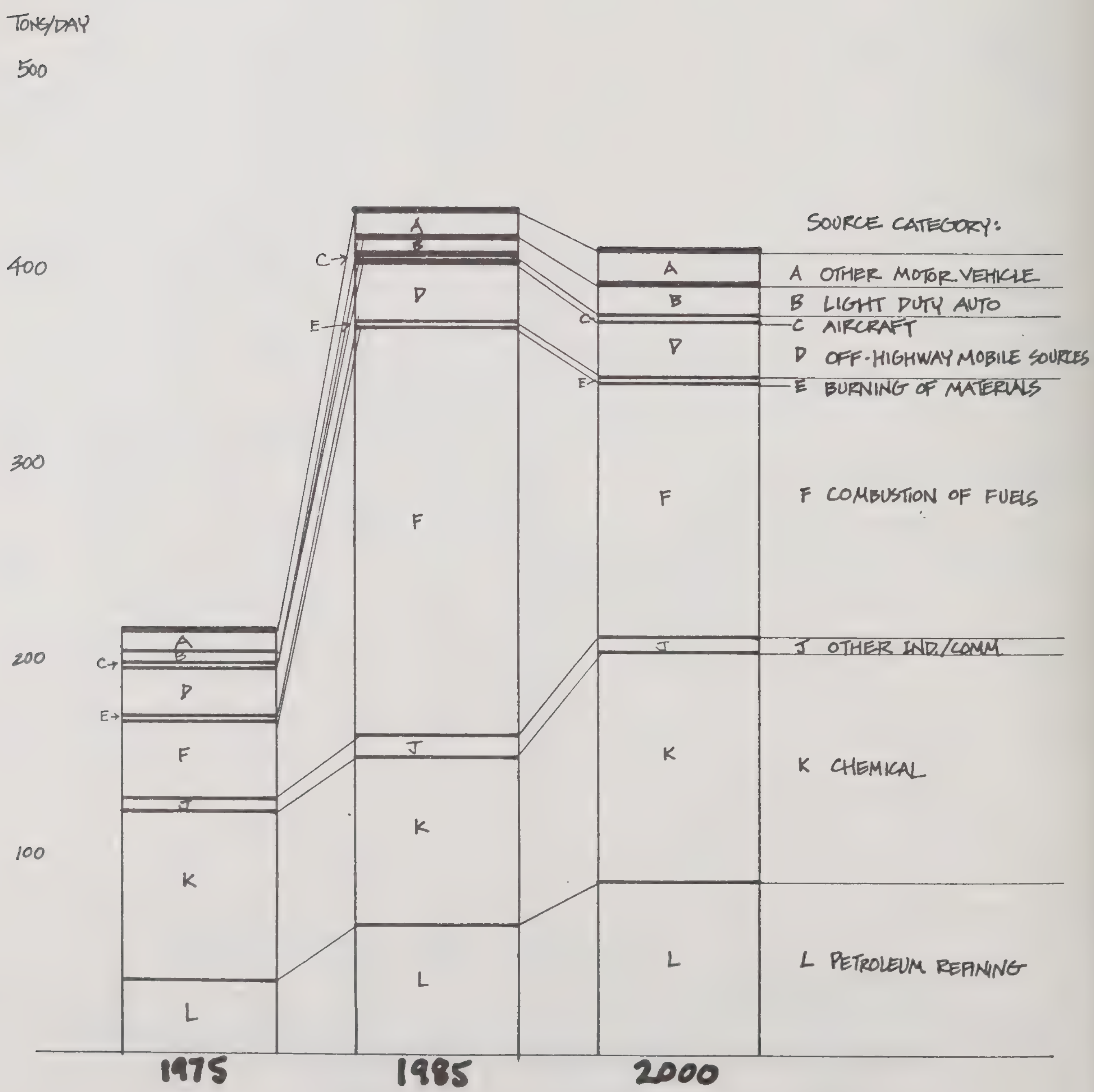
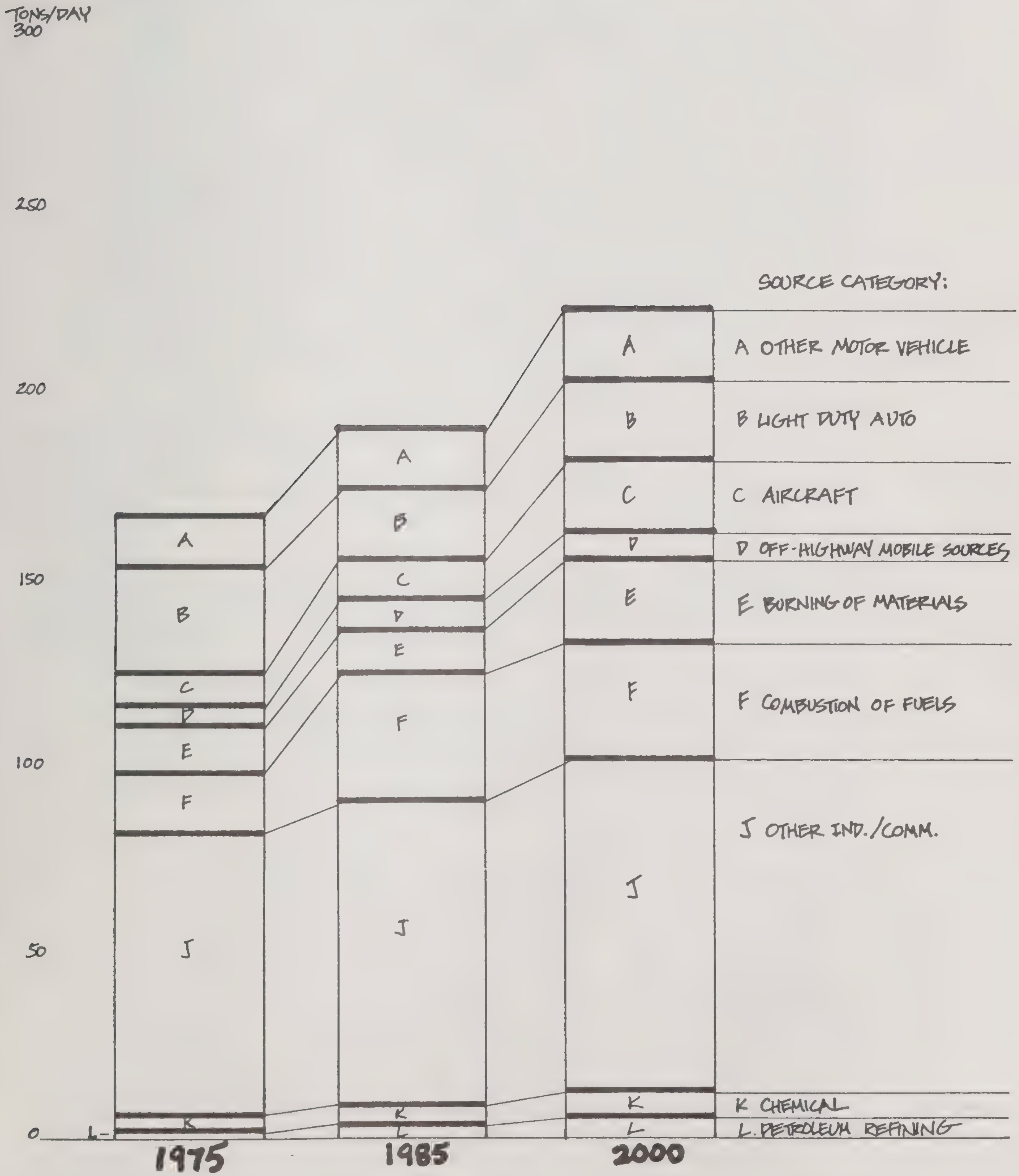


FIGURE 11

PARTICULATES EMISSION TRENDS

SAN FRANCISCO BAY REGION



AIR QUALITY TRENDS

Based on historical air monitoring data, the emission inventory projections, and air quality models, it is possible to forecast air quality trends. These trends project future air quality assuming no additional controls beyond those in place or scheduled.

- Photochemical Oxidants - Oxidants (primarily ozone) are formed in the atmosphere from emissions of hydrocarbons and oxides of nitrogen. From the emission inventory projections, hydrocarbon emissions are expected to decline moderately by 1985, and to rise back to the 1975 level by the year 2000. Oxides of nitrogen are projected to remain relatively constant from 1975 to 2000. (If P.G. & E. is not successful in bringing nuclear facilities "on-line", somewhat larger NO_x emissions may be expected by 2000.) These projections suggest that oxidant levels will be moderately reduced (an approximate 10 to 20 percent improvement) by 1985, but this improvement will not be maintained through the year 2000. Air quality data collected over the past several years indicate a slow trend toward lower oxidant levels and it is expected that this trend will continue for several more years. Somewhere around 1985, the trend will reverse if no further controls are implemented.

- Carbon monoxide - By far the dominant source of carbon monoxide emissions is motor vehicles. By 1985, a modest improvement of about ten percent will occur due to State and Federal motor vehicle control programs. By 2000, however, a substantial increase in CO levels beyond those experienced in 1975 will occur. The number of vehicles and the number of miles driven in the region are projected to increase by about 75 percent between 1975 and 2000. It is apparent that the emission control technologies currently used for automobiles and trucks will be insufficient to prevent continuing violations of the CO standard in the Bay Area.

- Sulfur dioxide - Sulfur dioxide emissions are projected to double by 1985, due primarily to the expected switch from natural gas to fuel oil and coal in electric utility and industrial boilers. Consequently, it is expected that SO_2 levels will increase substantially. The increased emissions are not projected to result in violations of the Federal standards. Recently, California revised its standards for SO_2. This revision complicates the assessment of the impact of emission increases on compliance with the SO_2 standard because it is now dependent on oxidant and particulate levels. Neither historical data bases nor available modeling techniques are ready to address the new standard at this time.

- Total suspended particulates - Emissions of particulate matter are projected to increase steadily from 1975 to 2000. As previously described, both Federal and State standards for particulates are violated in the region by a small margin. The significance of the increased emissions with respect to future violations cannot be assessed with existing data. The two largest components of particulate matter in the Bay Area's atmosphere are organic matter and dust. The development of a control strategy must await the collection of more refined data to identify the nature and sources of the particulates in the air.

- Nitrogen dioxide - The Federal standard for nitrogen dioxide is not currently violated. In addition, the emission inventory projection for NO_x does not indicate a significant increase in NO_x emissions. The conclusion is therefore that no future violations of the nitrogen dioxide federal standard are expected. California has a 0.25 ppm-one hour average NO_2 standard. In 1976, this standard was violated several times in a few Bay Area locations.

BASELINE LIRAQ RESULTS[3]

Attainment and maintenance of the photochemical oxidant standard is generally recognized as the most difficult air quality problem facing the Bay Area.

To assist in the analysis of alternative control strategies, the AQMP-Joint Technical Staff is using a state-of-the art photochemical model, generally referred to as the LIRAQ[4] model. Two detailed information sets constitute the main input requirements for LIRAQ:

1. Present and projected emissions for seven pollutants giving the hour by hour emissions for each pollutant within each 5 kilometer grid square in the region. These emissions are for every type of source--automobile, industry, airports, and general population.

2. Observed and adjusted winds and inversion height data varying hour by hour within each 5 kilometer grid square in the region.

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[3]The assistance of Drs. Michael MacCracken and Bill Duewer of the Lawrence Livermore Laboratory, and others of the LLL and BAAPCD staffs, is acknowledged for producing these results under severe time constraints.

[4]LIRAQ (Livermore Regional Air Quality) was developed over the past several years under National Science Foundation sponsorship to the Lawrence Livermore Laboratory, NASA Ames Research Center, and the Bay Area Air Pollution Control District. It represents more than a million dollar investment to produce a state-of-the art computer model for applications such as AQMP planning. To our knowledge, the EMTF is the only policy body of locally elected officials to have such a policy tool for formulating photochemical oxidant control strategies.

The inventories described in the previous section have been used in the LIRAQ model to produce baseline air quality projections. These projections describe air quality trends anticipated assuming existing air pollution control programs and others adopted and scheduled for implementation (again with the exception of New Source Review excluded as previously noted). Assuming July 26, 1973 prototype meteorology, the results of the LIRAQ model are summarized in Table 5. The region wide high projected for all three years (1975, 1985 and 2000) is situated 9.5 kilometers south-southeast of Livermore. In 1975, this high is projected to be 0.17 ppm, decreasing by 1985 to 0.13 ppm and rising again in 2000 (due to projected emissions increases) to 0.17 ppm. Figures 12-14 illustrate photochemical oxidant contours for the region during the worst hour on the prototype day projected for 1975, 1985 and 2000 respectively.

TABLE 5. BAY AREA BASELINE AIR QUALITY PROJECTIONS (1975-2000)

JULY 26, 1973 PROTOTYPE DAY

	1975	1975	2000
Location of Regional High Hour Ozone	9.5 Kms SSE of Livermore	9.5 Kms SSE of Livermore	9.5 Kms SSE of Livermore
Regionwide High Hour (ppm)	.17	.13	.17
Monitoring Station with Higest Ozone	Livermore	Livermore	Livermore
Ozone at Highest Station (ppm)	.13	.10	.13
Projected Oxidant Maximum at Individual Stations (ppm)			
San Francisco	.02	.02	.02
San Rafael	.02	.02	.02
Pittsburg	.04	.03	.05
Livermore	.13	.10	.12
Fremont	.07	.05	.06
San Jose	.13	.09	.13
Redwood City	.09	.06	.07
Concord	.06	.05	.06
Richmond	.04	.03	.04
Half Mood Bay	.03	.03	.03
San Leandro	.07	.05	.06
Los Gatos	.07	.05	.07
Vallejo	.05	.04	.04

NOTES: 1) Prototype day assumed is July 26, 1973. On this day the maximum oxidant level recorded was 0.18 ppm monitored in Livermore.
2) The Federal photochemical oxidant standard is 0.08 ppm - one hour, not to be exceeded more than once per year.

FIGURE 12. LIRAQ BASELINE AIR QUALITY - 1975
(Projected Regional Oxidant Maximum)

105

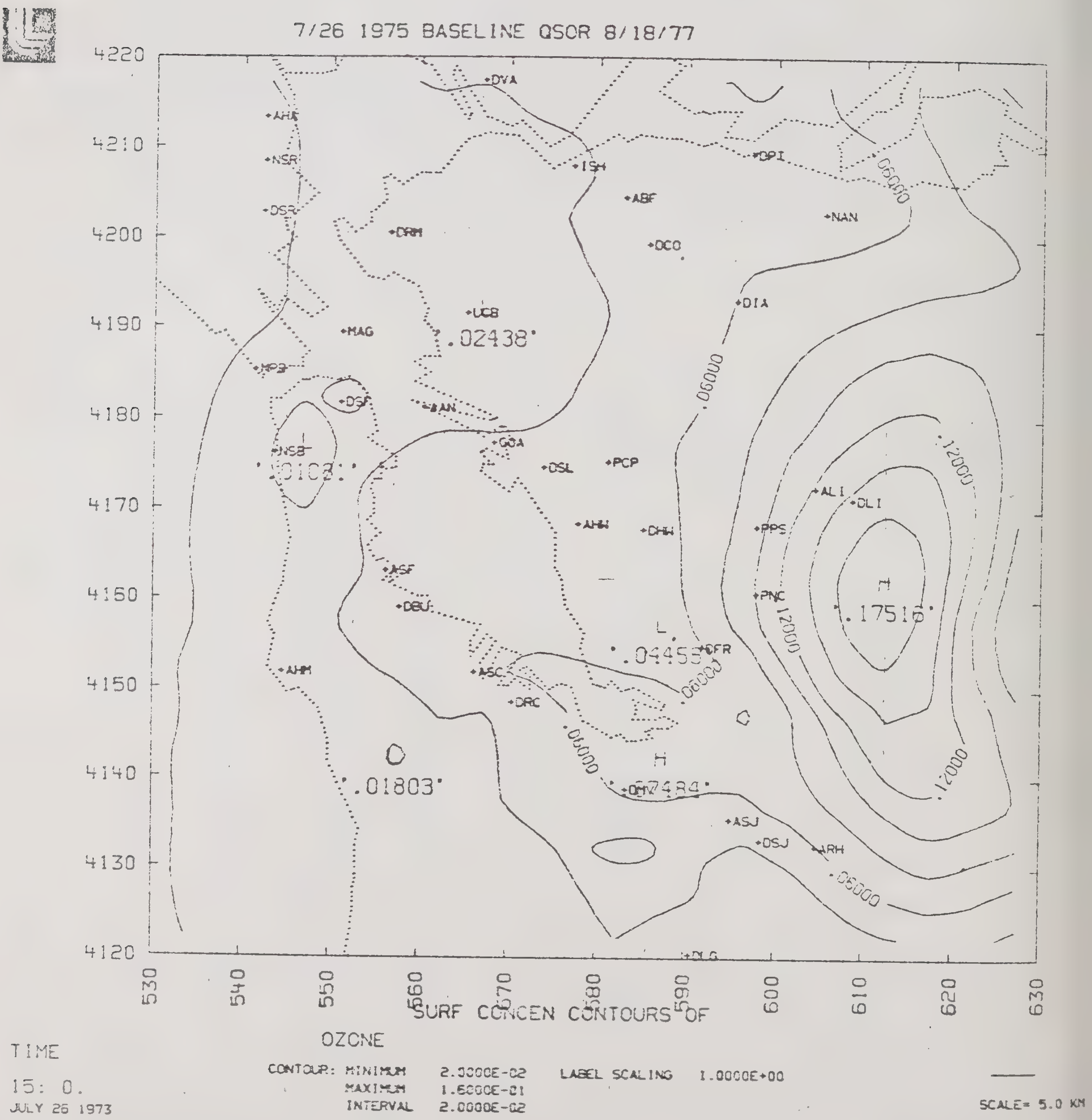


FIGURE 13. LIRAQ BASELINE AIR QUALITY - 1985
(Projected Regional Oxidant Maximum)

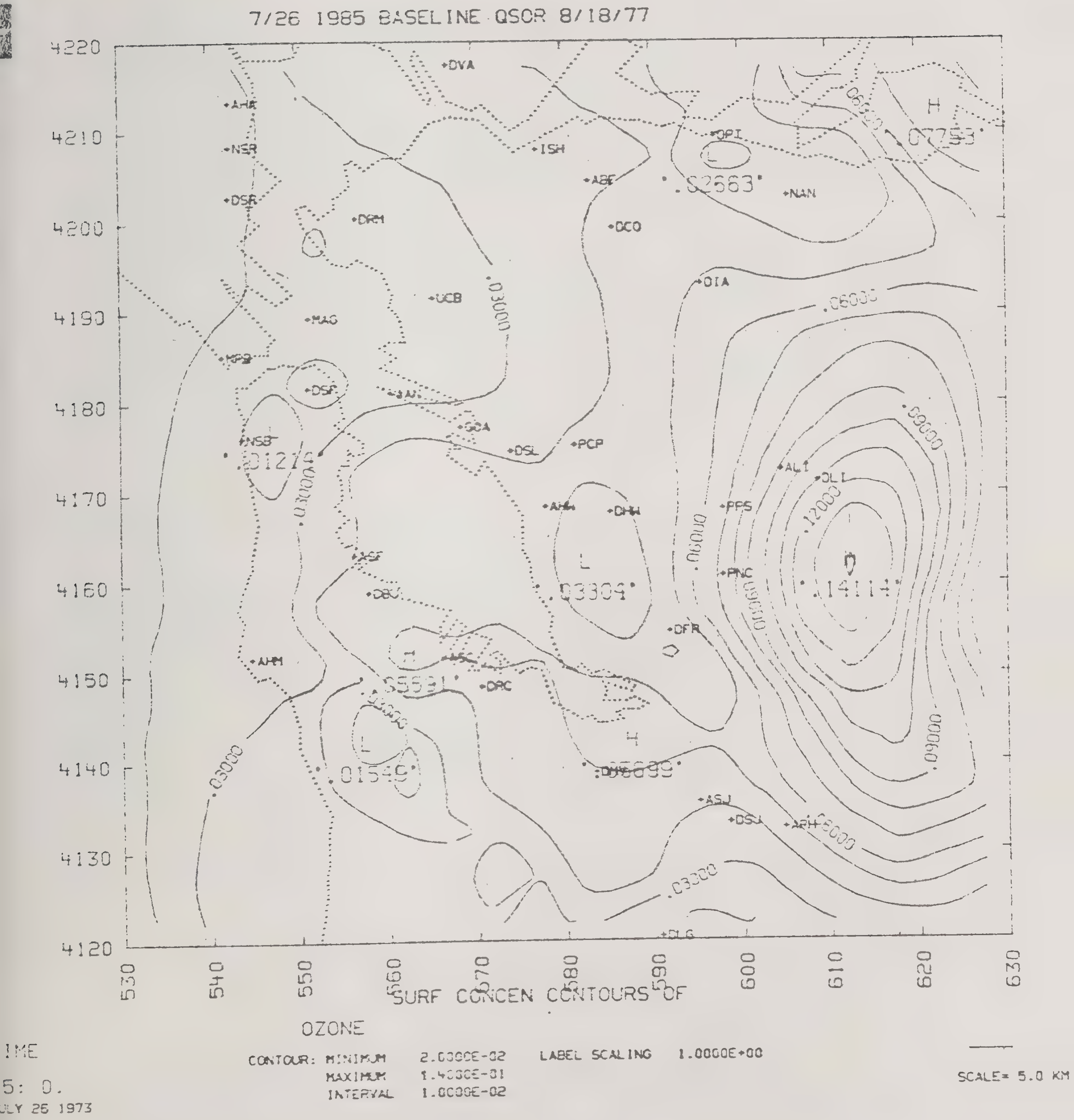
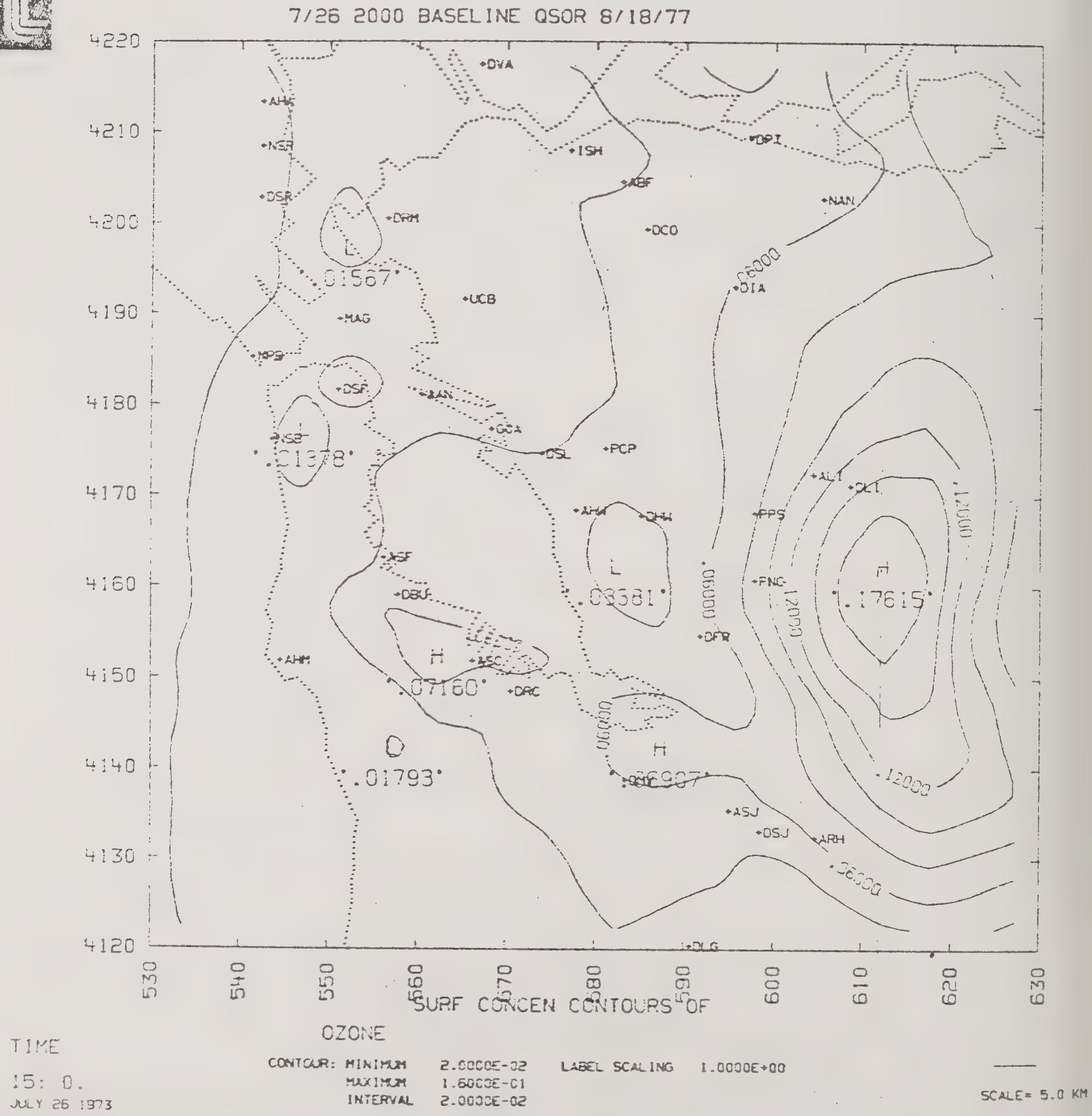


FIGURE 14. LIRAQ BASELINE AIR QUALITY - 2000
(Projected Regional Oxidant Maximum)

109



EMISSION REDUCTION REQUIREMENTS

The previous sections indicate that the most severe problem in the Bay Area is photochemical oxidants. The magnitude of emission reductions required to achieve the oxidant standards has never been adequately estimated for the Bay Area. Previous efforts relied on the use of technically limited "roll-back" calculations to estimate necessary emission reductions. The air quality maintenance plan is using a state-of-the art photochemical model (LIRAQ) to estimate more precisely the emission reductions required to meet the oxidant standard and in that sense to estimate the magnitude of the problem.

To address these issues, a series of sensitivity tests have been constructed.[5] The first series tests the effects of hydrocarbon control alone, and of hydrocarbon control combined with NOx control. Each of these tests assume a uniform reduction in emissions across the region from all source categories. Time permitting, this series will be followed by a second series which will be designed to test emission controls with differing spatial and/or temporal effects. By exercising the model in these tests we can gain insight concerning what controls will be effective in reducing oxidant levels in the Bay Area.

RESULTS OF INITIAL SENSITIVITY TESTS

As of this writing, two tests have been completed. The first test was an 80 percent reduction in all hydrocarbon emissions in 1985. The second test was an 80 percent reduction in all hydrocarbon emissions in the year 2000. The results of these tests, which used the July 26, 1973 prototype day, are summarized in Table 6. As shown in the table, oxidant levels are substantially reduced in both tests. Since the oxidant standard is .08 ppm (1 hour), LIRAQ forecasts that an 80 % hydrocarbon emission reduction will result in attainment of the standard on the prototype day. Preliminary staff evaluation of LIRAQ output for these tests indicates that the low oxidant levels forecast are due to the relatively large amounts of unreduced NOx emissions suppressing oxidant formualtion in the geographic areas covered by the model.

Work is continuing on the first series of sensitivity analyses. Results of these tests will be presented to EMTF at the August 31, 1977 meeting.

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[5]For further details, see AQMP/Tech Memo 7, "Development and Analysis of Alternative Air Qulaity Strategies," July 1977.

TABLE 6. SUMMARY OF INITIAL LIRAQ SENSITIVITY TEST RESULTS
July 26, 1973 Prototype Day

	Maximum Oxidant Concentrations (ppm) by Station		
	1975	1985*	2000*
Location of Regional High Hour Ozone	9.5 Km SSE of Livermore	Near Montezuma Hills	Near Montezuma Hills
Regionwide High Hour (ppm)	.17	.04	.04
Monitoring Station with Highest Ozone	Livermore	Vallejo	Half Moon Bay
Ozone at Highest Station (ppm)	.13	.03	.03
Individual Stations			
San Francisco	.02	.02	.01
San Rafael	.02	.02	.02
Pittsburg	.04	.02	.03
Livermore	.13	.03	.02
Fremont	.07	.01	.01
San Jose	.13	.01	.01
Redwood City	.09	.03	.03
Concord	.06	.03	.03
Richmond	.04	.02	.02
Half Moon Bay	.03	.03	.03
San Leandro	.07	.03	.02
Los Gatos	.07	.02	.02
Vallejo	.05	.03	.03

*with an assumed 80% reduction in hydrocarbon emissions

FINAL PRODUCT

The previous sections have documented the problems and causes. Estimates have been made of the solution required. This section describes the approach to developing a comprehensive air quality strategy for dealing with the remaining and projected problems.

BUILDING UPON EXISTING PROGRAMS

The foundation of the AQMP is existing air pollution control programs. These programs are either currently in force (such as the rules and regulations for stationary sources) or scheduled to be implemented in the near future (e.g., exhaust emission standards for heavy-duty vehicles and aircraft). Existing programs cover existing sources as well as future sources and are implemented by a variety of agencies. Thus, it follows that future controls are also likely to be characterized by:

1) Additional regulations for stationary and mobile sources

2) Controls on new and existing sources

3) Implementation by Federal, State and regional agencies

Where it is demonstrated that technological solutions are insufficient to solve the problem, transportation and land use controls must be considered.

AQMP REQUIREMENTS

The goal of the AQMP presumed passage of amendments to the Clean Air Act of 1970 to provide additional flexibility in the time allowed for meeting air quality standards. Further, it has been assumed that time extensions could be granted provided there was demonstration of:

1) Good faith efforts by State, regional, and local governments, and

2) Steady progress towards the goal

Earlier this month Congress passed the Clean Air Act Amendments of 1977. Provisions in the new Act allow for regions with severe oxidant and carbon monoxide problems to have until 1987 to achieve air quality standards. (See Appendix A for a summary of the Clean Air Act Amendments of 1977).

THE NEED FOR A COMPREHENSIVE STRATEGY

The AQMP requirements call for a comprehensive strategy which includes additional technological controls on stationary and mobile sources as well as transportation and land use controls. Table 7 is an updated version of control measures being analyzed by the Joint Technical Staff for inclusion in such a strategy. Most if not all of these measures would need to be implemented to have a significant impact on the remaining and projected air quality problems.

TABLE 5. ELEMENTS OF A COMPREHENSIVE AQMP STRATEGY

Stationary Source Measures	Mobile Source Emission Measures	Transportation Control Measures	Land Use/Development Control Measures	Land Use/Development Control Measures (cont.)
• High solids and water base coatings • Closed system organic storage • Limit max. SO_2 to 300 ppm or equivalent mass • Limit S content of fuel to 0.25% • BACT on new and existing sources • Continue NSR as is or with some sort of trade off	• More stringent vehicle (light duty & heavy duty) exhaust emission controls--approx. 50% reduction below 1977 prescribed levels • Inspection/maintenance program for light-duty vehicles • Inspection/maintenance program for other vehicles (including heavy duty vehicles) • Heavy duty gasoline exhaust retrofit	• Toll increase • Regional parking strategy • Additional transit service • Bus and carpool lanes/ ramp metering • Auto-control zone in San Francisco CBD • Para-transit services • Bicycle systems	<u>Reduce Long Distance Auto Commuting</u> • Restrict extension of new development to those locations with existing or commited sewer and water services • Expedite completion of needed sewer or water service improvements in all suitable locations within or contiguous to existing urban areas • Encourage "infill" development of bypassed vacant land within existing urbanized areas. • Increase housing and job opportunities in existing urbanized areas. Encourage public and private rebuilding of mixed land uses at higher densities • Encourage urban development in north bay jurisdictions where urban service capacity exists or can be committed by joint local/regional/ State action. • Restrict development in south bay jurisdictions to a population or employment level consistent with existing or committed urban service capacities. <u>Reduce the Number of Auto Trips and Increase Transit Usage</u> • Encourage higher density	development in urban areas where existing or committed service capacities, including rail transit, can support higher densities. • Discourage development of land within urban service areas where soil, slope, or other conditions can support only low density development • Delay auto-dependent land development which would preclude pending transit improvements • Encourage a mixture of residential/commercial/industrial development types in all communities • Discourage new large scale land development projects that are exclusively commercial/ industrial or residential. <u>Increase The Efficiency of Transportation Systems To Avoid Congestion</u> • Integrate the timing of highway and transit improvements with local policy on sequence of land development • Program funding of needed highway and transit improvements consistent with development sequence zoning.

PROGRESS AND SCHEDULE

Significant progress in developing the AQMP has been made. Nevertheless, the program is about 1-2 months behind schedule. The delays are primarily due to three factors:

1. All of the regional agencies (ABAG, BAAPCD and MTC) have encountered technical problems in their respective modeling tasks.

2. In early July, following the publication of revised emission factors for motor vehicles by EPA, the CARB directed the Joint Technical Staff to use the most current data in the AQMP. The net effect was certain tasks had to be repeated and a 1-2 week delay occurred.

3. Access to the Lawrence Berkeley Laboratory computer facilities has not been as good as hoped for. Even with the EMTF resolution restoring priority treatment to AQMP work, the Joint Technical Staff has been frustrated in getting onto the facilities as often as they would like.

Staff is working on ways to improve overall efficiency without sacrificing the technical quality of the work. The current deadline for completing a draft AQMP is mid-September. Every effort will be made to meet such a deadline.

SUMMARY OF ADVISORY COMMITTEE COMMENTS

COMMENT	RESPONSE
The methodology for projecting the base-line emissions appears to be inconsistent; the baseline covers all the rules and regulations currently on the books except New Source Review (NSR).	The existing BAAPCD New Source Review rule was not included in the baseline projection because continuation of the rule in its present form is uncertain. By projecting emissions under normal growth without the influence of New Source Review, all control measures including alternative NSR rules may be evaluated against the same yardstick.
The requirement of best available control technology should be separated into two control measures: for new and existing equipment. For new large installations it is virtually de facto in effect; to apply this to existing emission sources could be very expensive.	Staff will reflect this distinction in future write ups. Estimates of costs and effectiveness which have been made to a limited extent assume this difference, although the estimates made are reported together.
A list of best available control technologies is required in order to enable an assessment of this control measure.	This information is available and will be presented in a subsequent Tech. Memo.
There is a need for further clarification of the methodologies and problems in measuring, monitoring and projecting emissions.	Detailed documentation has been prepared for various aspects of the projections. Rather than reprinting the volumes of reports, the Joint Technical Staff suggests that individuals with specific questions or interests contact the JTS for discussion.

COMMENT	RESPONSE
It appears that a significant if not primary cause of the projected growth in emissions is due to growth in population. Land use controls would simply serve to redistribute the population. Thus, Table 5 in Brief No. 3 should include an additional column for Population Control Measures	Population controls have not been proposed because of the difficulty of devising effective controls that are not unconstitutional. Birth rates in the Bay Area have recently been below the rate necessary for replacement and are projected to continue at the low level. The rate of in-migration is the primary cause of the projected growth; thus, effective controls would have to reduce the rate of in-migration, and would in turn face serious constitutional and enforcement difficulties.
The onus or burden of solving the air quality problem appears to fall on land use development control measures: thirteen land use measures versus six for stationary, four for mobile source and seven for transportation. This appears to be inequitable.	The land use control policies listed are many in number because the legal, administrative and institutional structure for controlling land development is quite complex, involving many different agencies and control methods. Controls in other areas are fewer in number but equally as significant as the land use controls.
Some of the land use/development measures appear to be redundant, e.g., one measure is to encourage a mixture of residential/commercial/industrial development types, and another measure is to discourage new large scale land development projects that are exclusively commercial/industrial or residential.	The measures were organized to include policies which positively encourage the desired objectives and to negatively discourage development which would be counter to the desired objectives. While some overlap results, it is not considered redundant.
Will there be further documentation to describe how land use assumptions as reflected in Series III are translated into air quality impacts?	A number of documents dealing with this issue have already been prepared for review. Further information may be obtained by contacting the appropriate individual on the Joint Technical Staff.

SPECIFIC COMMENTS FROM PACIFIC GAS AND ELECTRIC COMPANY

COMMENT	RESPONSE
1. We suggest that any limit to the sulfur content of fuels should be accompanied by a provision to allow the option of limiting fuel gas sulfur content to an equivalent concentration. This would provide the owner of the source with some flexibility of fuel supply while maintaining sulfur dioxide emissions at the prescribed level. For example, PG&E has obtained a supply of 0.7 percent sulfur coal from Utah. It has a heating value of 12,000 Btu per pound and is considered to be one of the lowest sulfur coals available in the United States. Eastern coals of comparable heating value have sulfur contents of 2.5 and 4 percent. Without the above suggested option, a limitation on sulfur content of coal would preclude its use for fuel in the Bay Area. A decision to limit sulfur content to 0.25 percent would significantly disrupt the low sulfur fuel oil market. Any proposal to lower the sulfur content of fuel oil should be carefully coordinated with an analysis of the overall availability of suitable crude oils and a projection of refining capacity in order to assure the reliability of fuel oil supply to the Bay Area. The power generating facilities in the South Coast Air Quality Maintenance District are already limited to using 0.25 percent sulfur fuel. The Southern California utilities have indicated to us that at times there are not sufficient quantities of this fuel to supply all of the power plants in the area.	PG&E's concerns and comments are appreciated. The issues raised will be explored to the extent practical during the current planning phase. Should the particular SO_2 control measure survive and be included in the AQMP, additional study would be performed prior to its implementation.

SPECIFIC COMMENTS FROM PACIFIC GAS AND ELECTRIC COMPANY

COMMENT	RESPONSE
2. We concur that new and existing sources need to be treated differently. We respectfully suggest the following definition of Best Available Control Technology for new sources: "...best available control technology.... (will be) determined by the state board in consultation with the air pollution control district, taking into consideration, among other things, the engineering aspects, respective cost, reliability, and maintenance requirements of various types of control techniques; the fuels and raw materials available and to be employed by the source; any applicable state and local emission limitations; and locational and siting considerations. As a minimum, best available control technology shall require a level of emission control at least as stringent as the new source performance standards established by the Administrator of the Environmental Protection Agency pursuant to Section 1857c-6 of Title 42 of the United States Code." (Source: AB 471, passed State Assembly June 10, 1977, now being considered by the State Senate.) We would further suggest that the concept of Best Available Control Technology not be applied uniformly to existing sources. For a given existing emissions source category, such as boilers within a certain range of heat input, variables such as age of unit, manufacturer, and space limitations preclude a common interpretation of Best Available Control Technology.	The definition of BACT contained in AB 471 is sufficiently vague that no specific argument may be made against it. In evaluating the effectiveness of BACT, allowances were made for variances and exceptions to the rule, thus uniform application is not envisioned. The statement that standards should be designed to allow the least efficient unit to achieve compliance without having to cease operations sets an overriding criterion which is inconsistent with the goals of the Environmental Management Plan. The Environmental Management Task Force and other policy bodies will decide what reasonable costs will be borne in this region.

SPECIFIC COMMENTS FROM PACIFIC GAS AND ELECTRIC COMPANY

COMMENT	RESPONSE
In addition, the uniform application of Best Available Control Technology to all existing sources, regardless of category or pollutant emitted, would seem to be inappropriate methodology for solving specific air quality problems. Instead, it would seem more logical to continue the present practice of setting emission standards for existing sources in order to achieve specific goals in the State Implementation Plan. These standards would be designed, as they have historically been, to allow the least efficient unit for a given source category to achieve compliance without having to cease operations.	

COMMENTS FROM ASSOCIATED BUILDING INDUSTRY OF NORTHERN CALIFORNIA

COMMENT	RESPONSE
A. TOTAL SUSPENDED PARTICULATE (pg.3) Add - These geometric means do not differentiate contributions from windblown dust or secondary organics (photochemical aerosol). Until these unknowns are better defined, it is difficult to properly interpret the relative significance of the values in Figure 2.	This point is made elsewhere in the brief.
B. PHOTOCHEMICAL OXIDANT (pg.4, at end of 1st paragraph): Add - The oxidant concentration naturally occurring (i.e. background level) is unknown, but believed to be 0.04 to 0.05 ppm.	This point has been made to EMTF in a separate memo.

COMMENTS	RESPONSE
C. SUMMARY OF THE EMISSION INVENTORY (pg.11, 2nd paragraph after the 2nd sentence concerning hydrocarbons): Add - Although not included in this inventory, controls have been imposed on organic compounds evaporation (e.g. architectural coatings). The empirical formula representing oxidant formulation is a function of hydrocarbons (HC) and nitrogen oxides (NO_x); the relative amounts are not well defined.	The inventory includes all controls now on the books except New Source Review. An architectural coatings rule is currently being developed by the California Air Resources Board, but has not yet been adopted. Thus, it was not included in the baseline projections.
D. Figure 7 (pg.16): (G Other Compounds Evap.*) Add - * Existing Organic Solvent Controls not included.	See previous comment.
E. Figure 8 (pg.18): (F Combustion of Fuels*) Add - * Existing New Source Review regulations not included.	The appropriate qualifier is included in the text.
F. Figure 10 (pg.19): (F Combustion of Fuels*) Add - *Existing New Source Review regulations not included.	The appropriate qualifier is included in the text.
G. Figure 11 (pg.20): PARTICULATES EMISSION TRENDS: Add - Relative percentages of windblown dust and photochemical aerosols unknown.	The appropriate qualifier is included in the text.
H. BUILDING UPON EXISTING PROGRAMS (pg.24, last sentence): Revise - Where it is demonstrated that technological solutions are insufficient to solve the problem, population, transportation and land use controls must be considered. (Comments: Staff should not arbitrarily delete a realistic control strategy; EMTF should make that choice.)	(See response to previous comment on population control.)

COMMENTS FROM ASSOCIATED BUILDING INDUSTRY OF NORTHERN CALIFORNIA

COMMENTS	RESPONSE
I. THE NEED FOR A COMPREHENSIVE STRATEGY (pg.25, line 3): Revise - ...as well as population, transportation and land use controls.	(See response to previous comment on population controls.)
J. Table 5 - ELEMENTS OF A COMPREHENSIVE AQMP STRATEGY (pg.26): Add this column - Population Control Measures o Distribute birth control information and devices o Tax incentives for families with 2 children or less o Tax disincentives for families with more than 2 children o Welfare reform incorporating less benefits for families with more than 2 children o Tax incentives for large numbers of people residing in one dwelling unit	(See response to previous comment on population control.)

APPENDIX

SUMMARY OF THE CLEAN AIR ACT OF 1977

Earlier this month after more than two years of extensive debate, Congress reached agreement on the Clean Air Act Amendments of 1977. The attached summary of the new Amendments has been provided by the Congressional Quarterly Inc. (August 13, 1977). Key provisions of the Act as they pertain to current AQMP efforts include:

1. Extending auto emission standards for two more years, through the 1979 models. These standards are tightened in 1980, and again in 1981, with a possible waiver for carbon monoxide.

2. Extended time tables for achieving ambient air quality standards. States submitting implementation plans by 1979 are given until 1982 to meet the standards. For regions with severe oxidant or carbon monoxide problems (such as the Bay Area), the deadline can be deferred to 1987 at the latest.

3. Acceptance of the principle in EPA's offset regulations, namely permitting new pollution sources only if the emissions from existing sources are reduced.

4. Permission to state (and local authorities) to implement any indirect source review program. EPA is specifically excluded from implementing such a program by itself.

5. Permits EPA to "withhold, condition, or restrict" the funding of sewage treatment grants under certain conditions. Among the conditions are where "construction of such treatment works...may reasonably be anticipated to cause or contribute to, directly or indirectly, an increase in emissions" resulting in continued violations of applicable air quality standards.

6. Establishes "planning procedures" where the metropolitan planning organizations or the air quality maintenance planning organization or the organization with both responsibilities shall prepare proposed revisions to the State Transportation Plan to satisfy requirements of the Act.

7. Authorizes to be appropriated beginning October, 1977, $75 million nationwide to prepare such plan revisions through an air quality maintenance planning process involving State, regional, and local governments.

Oil and Gas Use Tax

Schlesinger asked the Finance Committee to strengthen three tax provisions the House weakened.

First, he asked for a tougher tax on utilities and industries that burn gas and oil. The tax is designed to encourage companies to switch to coal. Schlesinger said the House weakened the bill's effectiveness by allowing too many exemptions.

Schlesinger asked the Senate to scrap all exemptions for industrial use of gas except where it is used as a feedstock in industries like petrochemicals, where products are derived directly from gas.

He asked the panel to simplify the complicated multitier user tax devised by the House for industrial gas use. Instead, he requested that industrial use of gas be taxed at a rate to make gas prices equal on a British thermal unit (Btu) basis to the price of distillate fuel oil. More conversion would result, he said.

The House-passed plan allows user taxes to be rebated to industries and utilities for qualified expenditures in equipment to convert plants to coal. Schlesinger requested that rebates to utilities be changed so that they could receive not more than $125 for each kilowatt of capacity retired or consigned to use for "peakload" purposes. Peakload power plants are used only when consumer demand exceeds normal levels. That would spread the rebates over more conversion projects, result in savings of an additional 300,000 to 400,000 barrels of oil equivalent per day and simplify administration of the tax, he said.

The Energy Secretary also asked that the tax on oil be set at $3 per barrel, simplifying the multi-tier oil tax system erected by the House.

Gas Guzzler Tax

Schlesinger asked for a stiffer tax on gas guzzling automobiles. He also asked that light duty trucks be taxed. The House omitted them from the levy, but Schlesinger said they constitute 25 per cent of new car and truck sales. *(Related story, Weekly Report p. 1628)*

Schlesinger also renewed, briefly, the administration's request for a standby gasoline tax which would possibly rise as high as 50 cents. The House killed that plan in committee and two modest floor proposals for new gasoline taxes of four and five cents per gallon were rejected overwhelmingly.

Finance Committee members, including Long, made it plain they had no sympathy for the standby tax proposal, and Schlesinger wasted little time discussing it.

Blumenthal Testimony

Treasury Secretary W. Michael Blumenthal Aug. 9 echoed Schlesinger's requests but omitted mention of the gasoline tax.

Blumenthal also asked the panel to extend the crude oil equalization tax beyond the House-approved cutoff date of 1981, and urged that rebates of revenues from that tax be made a permanent feature of the program. The House version provided rebates of the oil tax only for 1978. Blumenthal also said the rebates should be made on a per capita basis rather than on a per taxpayer basis.

Long strongly indicated he would prefer scrapping the rebates altogether and investing the revenue instead in development of energy resources like oil shale, solar and geothermal power, and in "plowing back" some of the tax money to oil and gas producers as an incentive for them to produce more conventional fuels.

Industry Testimony

In testimony Aug. 10, representatives of the nation's automobile industry told the panel that taxes on gas guzzling cars would burden the industry and consumers and lead to the end of "big family cars."

Representatives of the Edison Electric Institute, which represents privately owned electric utilities, told the panel Aug. 11 that the Carter energy program could cost consumers $60-billion in higher electric bills. Bills would rise as utilities attempt to pay for the Carter legislation's mandates to convert to coal and to install special meters, they said.

The Finance Committee was to hold one week of hearings on the Carter energy plan during the August recess and another soon after Congress returns Sept. 7. The panel hopes to report a bill by late September.

Major Provisions:

President Signs Revisions In 1970 Clean Air Law

President Carter has signed into law clean air amendments with a warning that new auto emissions deadlines will be enforced strictly.

Congress avoided last minute delays and gave final approval Aug. 4 to the Clean Air Act Amendments of 1977.

Carter signed the bill (HR 6161—PL 95-95) on Aug. 7 while on vacation in Plains, Ga.

Adoption of the conference report (H Rept 95-564) came only one day after House and Senate conferees reached agreement on the complex legislation early in the morning of Aug. 3. Both chambers adopted the report by voice vote. *(Conference story, Weekly Report p. 1629)*

Sen. Jake Garn (R Utah) objected to HR 6161 because of a provision to prevent significant deterioration of clean-air areas of the nation. In 1976, Garn led a filibuster on that issue that killed similar legislation in the 94th Congress. *(1976 Almanac, p. 128)*

This time, Garn complained but did not threaten to filibuster on the Senate floor. He was assured by the bill's manager, Sen. Edmund S. Muskie (D Maine), that the non-deterioration provision would not stop industrial growth in western states. Garn admitted to reporters later that he did not have the votes to sustain a filibuster.

In signing the legislation Aug. 7, President Carter said it would permit economic growth that is environmentally sound. He promised that the new auto exhaust timetable would be enforced strictly. He said the law provided automakers with a "firm timetable for meeting strict, but achievable, emissions standards."

Provisions

HR 6161 amended most sections of the 1970 Clean Air Act (PL 91-604). As passed by Congress, the legislation contained the following major provisions:

Title I—Stationary Sources

Non-Attainment Areas

Under the original law, all areas of the nation were to have attained national ambient air standards by mid-1977.

The amendments extended the deadline to Dec. 31, 1982, except that cities with especially severe oxidant and carbon monoxide problems were given an extension to Dec. 31, 1987. States having non-attainment areas were required to submit revised implementation plans in 1979 and again in 1982.

The plans of states seeking extension to 1987 must include alternative site analyses for proposed major sources of pollution, a schedule for implementing a vehicle inspection and maintenance program, and plans to improve public transportation. States with auto-related problems could adopt emission standards identical to California's. (California planned in 1982 to reduce the nitrogen oxide (NOx) level from 1 gram per mile to .4 gram—stricter than national standards.)

All revised implementation plans must contain a permit program for new or modified major facilities. Permits could be issued only if pollution offset requirements would be met or the new source would not exceed the new growth allowance. Prior to 1979, the EPA offset policy of Dec. 21, 1976, would be in effect in most non-attainment areas. New or expanded facilities would be required to use the best control technology and processes available.

Conferees on HR 6161 dropped the House provision to require equal reductions in emissions every two years. But they reported their intention that "regular, consistent emission reductions will be demonstrated through the mechanism of the implementation plan" up to the attainment deadline.

Governors were given authority, until they submitted revised plans, to suspend portions of existing transportation control plans dealing with on-street parking restrictions, gas rationing and retrofit of non-commercial vehicles.

Industrial Compliance

Stationary sources which directly emit pollution could obtain delayed compliance permission from the state or EPA allowing them to continue operations temporarily even though they violated emission limitations. Orders were limited to not more than a three year delay. No orders could be issued after July 1, 1979, unless they established delayed compliance penalties.

There were exceptions. Sources using innovative technology to control pollution were given up to a five year delay. Sources ordered to convert to coal were given until Dec. 31, 1980, to comply with state implementation plans, with authority for an additional delay up to five years. Primary nonferrous smelters operating at the time of enactment could be given two delayed compliance orders, the first until Jan. 1, 1983, the second until Jan. 1, 1988.

Penalties were designed to make noncompliance more expensive than compliance. Assessments must be no less than the quarterly equivalent of the capital costs of compliance and debt service over a normal amortization period, operation and maintenance costs foregone as a result of noncompliance, and the additional economic value gained by delay in compliance beyond July 1, 1979.

Nondeterioration

The legislation established three categories for areas having air cleaner than national ambient standards.

Mandatory Class I areas were all international parks regardless of size, national memorial parks and wilderness areas exceeding 5,000 acres, and national parks exceeding 6,000 acres. Class II initially included all other clean-air areas, and they might be redesignated. Class III areas would be designated following hearings and studies, but several types of public lands exceeding 10,000 acres would not be eligible for Class III designation. Redesignation of federal lands requires consultation with the federal land manager.

The legislation set increments for the maximum allowable increases of particulates and sulfur dioxide for each of the three classes. Within two years EPA was to propose increments or other means for preventing significant deterioration from nitrogen oxides, hydrocarbons, carbon monoxide and oxidants. These regulations would take effect in one year, when revision of state plans would begin. States could adopt control strategies other than increments for the four pollutants.

A variance above the sulfur dioxide increments only could be granted for up to 18 days a year in Class I areas, with different increments for high- and low-terrain areas as defined by the act. A violation of three hours in one day was considered a violation for the entire day. The governor could grant the variance only after public hearings. If the Secretary of Interior or other Cabinet officer in charge of the lands opposed the variance, the President would have to decide the issue within 90 days.

State plans must require permits for pollution sources in clean-air areas, with conditions specified in the law. Indian tribes were authorized to redesignate tribal reservation lands as Class I or Class II.

Visibility Protection

The legislation included major parts of a House provision to reduce visible pollution in mandatory Class I areas.

Within six months the Interior Secretary was to identify all federal Class I areas where visibility is an important value. Interior and EPA would list such areas and recommendations for improvement within one year and periodically when appropriate.

States must identify the sources that impair visibility, and set emission limitations based on the best available retrofit technology for each source. Requirements of this section must be included in state implementation plans.

New Source Standards

Performance standards for new sources of pollution were revised.

Boilers fired by fossil fuels were required to use "the best technological system of continuous emission reduction," no matter if they used untreated low-sulfur coal as a step toward compliance. Standards for such sources included both performance standards for emissions and a percentage reduction in pollution from untreated fuel. EPA was permitted to set a range of pollutant reductions to reflect varying fuel characteristics.

Waivers from the new source performance standards could be granted on a unit-by-unit or source-by-source basis to permit use of innovative continuous emission control technology. But the cumulative period of all waivers could not exceed seven years after the first waiver was granted to that unit or four years after the unit began operating, whichever occurred earlier.

Enforcement

The law authorized the courts to impose civil penalties of up to $25,000 per day for violations of the act. Knowing violations of the delayed compliance penalty provisions were made subject to criminal sanctions.

Implementation Plans

States were directed to revise implementation plans to meet new requirements of the law. Plans must include air quality maintenance measures and preconstruction permit requirements.

EPA was prohibited from requiring indirect source review programs, except with respect to certain federally funded projects. However, state and local governments were allowed to adop and enforce such programs.

This section also:

• Required that preconstruction reviews of direct sources include consideration of energy, environmental and economic impacts.

• Provided that implementation plans require the payment of permit fees by the owner or operator of major stationary sources.

• Prohibited owners or operators of stationary sources from making employees bear the costs of periodic shutdowns or production curtailments undertaken as supplemental or intermittent control measures.

Control Regions

Each state was required to send to EPA, within 120 days of enactment of the law, a list identifying air quality levels within its control regions. EPA was given 60 days to approve each list.

Governors were authorized to revise the boundaries of air quality control regions within their states in order to improve management.

Air Quality Standards

EPA must review criteria for ambient air quality standards by Dec. 31, 1980. Subsequent reviews of standards are required at least once every five years thereafter. The EPA Administrator must appoint an independent scientific committee of seven members to recommend new standards.

Within one year of enactment, EPA must set a national primary standard for nitrogen dioxide concentrations over a period of not more than three hours.

Other Provisions

Other sections of Title I did the following:

• Prohibited EPA from charging fees for training employees of state and local air pollution control agencies.

• Required EPA to publish information on basic transportation control measures within 180 days of enactment, and information on additional measures within one year.

• Gave the governors authority to temporarily suspend state implementation plans when there is a presidential finding of an energy or economic emergency in the nation or region. However, only the President was authorized to suspend federal standards or requirements.

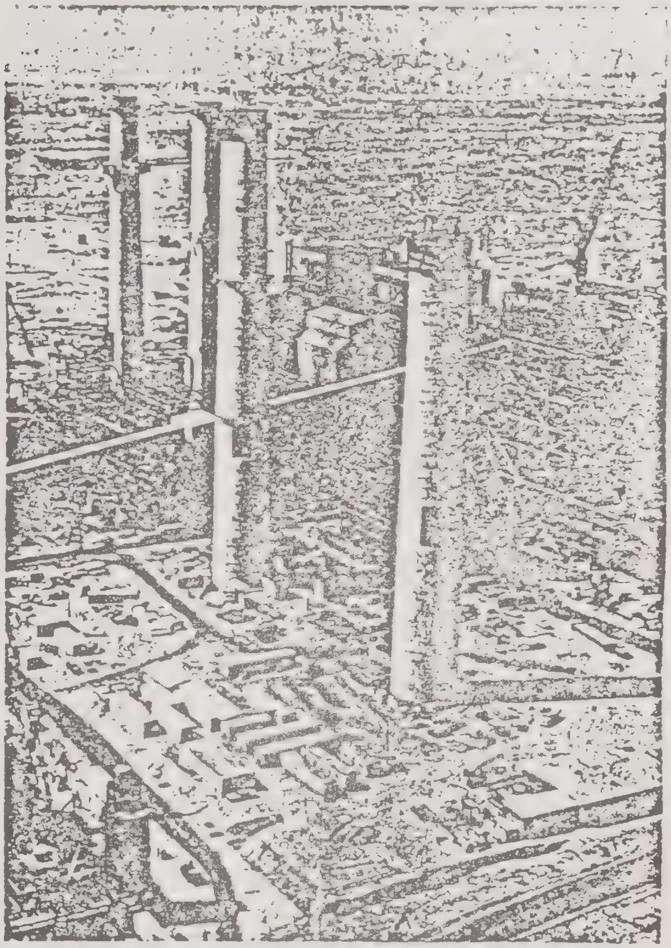
• Authorized EPA to establish design, equipment or operational standards when it is not feasible to set emission standards for hazardous air pollutants.

• Authorized EPA to require revision of state plans to prevent or eliminate air pollution dangers to persons in foreign countries.

• Abolished the President's Air Quality Advisory Board.

• Required federal facilities to comply with all procedural and substantive requirements of the law.

• Classified radioactive substances as air pollutants, and required EPA to study several unregulated pollutants for possible inclusion under the act.



A power plant owned by the Public Service Company of New Mexico has no visible discharge from the stacks. Many of the structures around the stacks house equipment to remove pollutants before gases are discharged into the air.

• Stated that tall stacks are not a means of emission limitation under the act, but made one exception for a 20-year-old steam plant operated by the Tennessee Valley Authority.

• Provided that the President or governor might require the use of local coal by certain plants in order to prevent severe economic disruption or unemployment.

• Provided for interstate cooperation to reduce air pollution.

• Required members of state boards with permit or enforcement authority under the act to disclose potential conflicts of interest, but let the states determine specific requirements.

• Required the states to notify the public of air pollution levels exceeding primary standards, and to educate the public about hazards and improvement measures.

• Provided for continuing research on the effects of various substances and activities on stratospheric ozone.

Title II—Mobile Sources

Auto Emissions

The 1977 standards of 1.5 grams per mile of hydrocarbons (HC), 15 grams of carbon monoxide (CO) and 2 grams of nitrogen oxide (NOx) were extended through model years 1978 and 1979. In 1980 the standards were tightened to .41

HC, 7 CO and 2 NOx. In 1981 and beyond they were set at .41 HC, 3.4 CO and 1 NOx. However, the CO standard for 1981 and 1982 could be waived up to 7 grams by the EPA if public health did not require the statutory standard and if technology to meet it did not exist. *(Emissions table, Weekly Report p. 1631)*

Other waivers were permitted for NOx. Small manufacturers, including American Motors Corp., that depend on emissions technology produced by other companies were given a two-year waiver until 1983 to meet 1 gram NOx. A waiver to 1.5 grams NOx for any four-year period after 1980 was permitted for certain innovative technology on up to 50,000 vehicles or engines produced by one company. A four-year waiver to 1.5 grams NOx was permitted for light-duty diesel engines as well, but only for model years 1981-1984.

The original statutory standard of .4 NOx was retained only as a research objective. EPA was to issue regulations within 180 days requiring manufacturers to build demonstration vehicles, and was to issue its own report by July 1, 1980.

High-altitude Vehicles

Existing high altitude regulations were suspended until 1981. Models 1981-1983 must meet standards based on percentage reduction no greater than those for all cars, based on emissions from 1970 cars operating at high altitudes. For 1984 and thereafter, cars must meet statutory standards at all altitudes.

Trucks, Buses and Motorcycles

EPA must set interim standards for HC and CO through 1982, with statutory HC and CO standards becoming effective in 1983 and statutory NOx in 1985. Statutory standards for heavy-duty vehicles mandate a 90 per cent reduction from baseline for HC and CO, and a 75 per cent reduction from baseline for NOx. Revision of any statutory standard requires four years of leadtime.

Tampering

Prohibited removal of or tampering with emission control systems by manufacturers and dealers, independent repair and service businesses, and selling, leasing, trading or fleet operations. Authorized civil penalties of up to $2,500 per vehicle.

Warranties and Parts

The legislation set a performance warranty of 24 months or 24,000 miles, during which the car manufacturer would have to bring into compliance with emissions standards any vehicle which failed an inspection and maintenance test. Catalytic converters, thermal reactors and other emission control devices must be warranted for five years or 50,000 miles.

Within two years of enactment, EPA was to provide regulations to certify parts made by other than the car manufacturer. Repairs and maintenance could be performed at any service shop using certified parts. The cost of any major part used principally for emission control and scheduled for replacement during the useful life of the vehicle must be borne by the manufacturer. Car owners were made responsible for properly maintaining vehicles and equipment.

Production Line Test

The final legislation did not include the Senate bill's provision for a production line test. But conferees recognized existing authority for EPA to test or require testing of new cars to see whether they comply with emission standards. The conference report directed EPA to revise test procedures to provide a short production line test that would "assure reasonable statistical certainty that each car produced will be able to pass an emissions inspection."

Fuels and Additives

Directed EPA to require manufacturers of fuels and fuel additives to test the potential health effects of their products, including the effect of a substance on emission control performance. Fuels or additives introduced into commerce or increased in concentration between Jan. 1, 1974, and March 31, 1977, must be removed no later than Sept. 15, 1978.

The legislation relaxed standards on lead levels in gasoline produced by small refineries, and directed EPA to set new standards for the period beyond Oct. 1, 1982.

California Waiver

EPA was authorized to grant a waiver from automobile emissions standards for California if EPA determines that the state standards are in the aggregate as protective of public health and welfare as the federal standards.

Title III—Miscellaneous Provisions

Emergency Powers

Authorized the EPA Administrator to issue emergency orders in a public health emergency and required him to bring civil suit within 24 hours of such orders. Violators could be fined up to $5,000 a day.

Citizen Suits

Allowed citizens to bring suit against sources to force compliance with emission standards or limitations, to prevent construction or modification of a major emitting facility without a permit, and to stop violation of conditions or requirements specified by the state or EPA under several provisions of the law.

Civil Litigation

The legislation retained existing provisions giving the Department of Justice primary responsibility for controlling and supervising civil litigation involving EPA. In addition, it gave statutory sanction for the June 13, 1977, memorandum of understanding between the department and EPA, and stated that all cases filed after enactment should be subject to it. The conference report detailed several items in the memorandum.

Courts were authorized to award reasonable attorneys' fees and other costs in judicial review proceedings when appropriate.

Administrative Procedures

The conference modified provisions in the House bill that changed the administrative procedures in EPA rulemaking and the standards of judicial review. The

Senate deleted application of proposed new rules in several instances, but generally concurred with House provisions. The courts were urged to continue thorough and comprehensive review.

Economic Impact Assessment

Required EPA to prepare an economic impact assessment on proposed regulations, with required analysis of five items. But EPA rules could not be challenged on failure to comply with this section.

National Commission

Established a National Commission on Air Quality of 13 members, including four from Congress. The commission was directed to make five studies in three years with a total authorization of $10-million.

Conflicts of Interest

Required financial disclosure by members of the Scientific Review Committee established in Title I, and prohibited conflicts of interest, one year after enactment, by officers and employees of EPA and officers of other organizations (including nonprofit organizations) engaged in activities related to air quality.

Employment Effects

Directed EPA to investigate, report and advise on the potential loss or shifts of employment resulting from the Clean Air Act. Protected employees who believed they were fired or discriminated against as a result of their testimony or legal action under the act, and authorized the Secretary of Labor to award compensatory damages for violations.

Sewage Treatment Grants

Authorized EPA to withhold, condition or restrict construction grants for sewage treatment plants under limited circumstances related to the Clean Air Act.

Air Quality Monitoring

Required EPA within one year of enactment to set regulations establishing a standard air quality index for monitoring and reporting by state and local governments.

Vapor Recovery

Required the owners of retail outlets to pay for vapor recovery equipment on fuel storage tanks and pumps within three years. Independent marketers selling less than 50,000 gallons of gasoline per month were not required to install and use the equipment, unless their state or local governments required it.

Authorization

Title III authorized $200-million each year for fiscal 1978-1981 to implement provisions not authorized elsewhere, and $4-million for each of the four years for notification grants to the states.

Gasoline Price Controls

The politically sensitive issue of gasoline price controls has arrived on Capitol Hill once again.

On Aug. 9, the Federal Energy Administration (FEA) announced plans to end gasoline prices controls Nov. 1.

The move would have "no adverse price or supply effects," the FEA said. Competition and market forces would suffice to protect consumers; gas supplies are adequate to meet demand through 1979, the agency said.

That may sound familiar. On Jan. 19, the last full day President Ford was in office, the FEA sent Congress notice of its intention to end gasoline price controls. The same reasons were cited then. It would not hurt consumers; it would stimulate competition; it would reduce government regulation.

Congressional Democrats responded to Ford's gasoline decontrol proposal with statements of opposition and outrage. Their opposition stemmed in part from resentment that the Republican President was ordering a controversial policy change on his last full day in power.

But their rhetoric also emphasized how much prices would rise, unfairly hurting the poor. Ford's proposal was certain to be rejected by Congress. Under the 1975 Energy Policy and Conservation Act, either house of Congress can veto such pricing actions within 15 days of their submission. *(Background, Weekly Report p. 81)*

But President Carter beat Congress to the punch, rescinding Ford's order Jan. 23.

Whether the gasoline decontrol proposal will provoke the same opposition now remains to be seen. Most legislators were away from Washington when Carter's announcement came.

The FEA will hold hearings on the proposal in September before formally submitting it to Congress.

On Aug. 2, FEA chief John F. O'Leary told a gas industry luncheon that the nation may face gasoline shortages in 1978 and 1979, which would appear to contradict the FEA's statement on the gasoline decontrol order.

And on Aug. 8, Transportation Secretary Brock Adams said he thought the price of gasoline would soon reach $1 per gallon.

Title IV—Studies

Administrative Standards

Provided a uniform standard of proof for EPA regulation of air pollutants applied to national ambient air quality, new stationary source performance, hazardous stationary source emissions, auto emissions, regulation of fuels and additives, and aircraft emissions. Authorized EPA to regulate any future air pollution from these sources.

Interagency Cooperation

Required creation within three months of enactment of the law a Task Force on Environmental Cancer and Heart and Lung Disease, led by EPA and including representatives of the National Institutes of Health, to conduct research programs and report to Congress annually.

Studies

The legislation required EPA and other agencies to conduct the following studies:

- Suspended particulate matter (18 months).
- Odorous emissions (by Jan. 1, 1979).
- A list of all known chemical contaminants that have been found in human tissue (12 months), and an explanation of the origin of these chemicals (18 months). If feasible, EPA was to conduct an epidemiological study of the relationship between levels of chemicals in the environment and in human tissue (no deadline).
- Air quality for the Gulf Coast and other areas, including analysis of liquid and solid aerosols (no deadline).
- Potential dislocation of employees due to implementation of laws administered by EPA (12 months).
- Health effects of auto-related pollutants, including sulfur compounds (annually).
- Sulfur-bearing compounds from motor vehicle engines and aircraft engines (12 months).
- Railroad emissions (six months).
- Economic measures to control air pollution (24 months).
- Penalties for NOx emissions from stationary sources (12 months).

—*By James R. Wagner*

Senate Passage:

Change in Pesticide Registration Approved

The Senate has passed legislation (S 1678) to make it easier for the Environmental Protection Agency (EPA) to complete the task of evaluating the safety of the tens of thousands of pesticides currently on the market. S 1678, approved July 29 by voice vote, also extended authorization for the pesticide program for two years, through fiscal 1979.

In 1972, Congress amended the 1947 Federal Insecticide Fungicide and Rodenticide Act to require that all pesticides be registered with EPA. Under the 1972 amendments, all products already registered under the 1947 law were required to be reregistered according to strict new environmental standards. *(1972 Almanac p. 934)*

But the EPA had fallen far behind in the reregistration process, which was supposed to be completed by October 21, 1977. A 1976 budget report estimated that it would take ten years to complete the process. New pesticides were being held off the market because of delays in registration.

S 1678 eliminated the deadline for reregistration and made a number of changes designed to speed up the process. It separated the registration process from the classification process under which pesticides were judged appropriate for general or restricted use. The classification process could thus be done more quickly. It also provided for public access to health and safety information supplied by pesticide manufacturers to meet EPA registration requirements.

The bill avoided much of the controversy that has surrounded the EPA pesticide program in recent years. Farmers have argued that EPA regulations impose burdensome restrictions on pesticides necessary for food and fiber production. Some environmentalists, backed by a January 1977 report by the Senate Judiciary Subcommittee on Administrative Practice and Procedure, have charged that the agency has failed to provide enough protection against potentially very dangerous chemicals. *(Background, 1975 Almanac, p. 201)*

Senate Action

The Agriculture Committee reported S 1678 July 6 (S Rept 95-334). The bill authorized $54.5-million for the program in fiscal year 1978, and up to $70-million in fiscal 1979.

The bill was intended to expedite the EPA registration and reregistration process, which the committee said had "ground to a virtual halt." One provision would allow the agency to study the safety of pesticides "generically," by analyzing the relatively few individual chemicals that go into the thousands of mixed preparations sold commercially. Current law requires that the agency study the safety of each of the separate chemical combinations sold.

The bill would also allow the agency to grant conditional approval to new pesticides even if all safety studies on the new compound had not been completed.

The EPA Administrator was authorized to waive the requirement that EPA evaluate the effectiveness of each pesticide, leaving that judgment up to those who used the product.

The committee attempted to resolve the continuing conflicts among pesticide producers over control of registration information. The 1972 law allowed firms registering new pesticides that were similar to previously registered products to use information already filed with the agency by another firm. Disagreements among producers over the proper compensation for use of the registration information have arisen repeatedly since then, giving rise to extended litigation.

S 1678 would establish new rules for settling disputes over compensation. Binding arbitration would be required if producers could not agree among themselves. Developers of original information would be due compensation for seven years after the information was originally submitted.

The bill would exclude from the category of protected "trade secrets" information on the effects of pesticides on health and safety. This would open the health and safety information to public scrutiny.

The Senate passed S 1678 without opposition July 29.

Before passage, the Senate by voice vote adopted amendments to the bill which:

- Stated that states had the primary enforcement responsibility under the law for dealing with pesticide use violations. Federal enforcement would be allowed only when it was clear that the state was not carrying out its responsibility.
- Restricted the circumstances under which a currently-marketed pesticide could be conditionally registered for a new use on a food or feed crop, if that pesticide or any ingredient in it has been determined to present an unusual risk to humans.

House Action

The House Agriculture Committee reported HR 7073, a simple one-year extension of the program, May 16 (H Rept 95-343). Floor action on the measure was delayed until after the August recess by the House's crowded schedule.

The House Agriculture Investigations Subcommittee is scheduled to begin consideration of substantive changes in the pesticide registration program September 7.

—*By Harrison H. Donnelly*

(ENERGY/ENVIRONMENT continued on p. 1742)

ENVIRONMENTAL MANAGEMENT PROGRAM

AIR QUALITY MAINTENANCE PLAN BRIEF NO. 4

PROGRESS REPORT ON DEVELOPMENT OF THE AIR QUALITY MAINTENANCE PLAN

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PREPARED FOR THE

ENVIRONMENTAL MANAGEMENT TASK FORCE

OCTOBER 12, 1977

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LIST OF TABLES

INTRODUCTION

This is the fourth of five briefs describing development of the Air Quality Maintenance Plan (AQMP). Previous briefs have discussed the goal of the AQMP, alternative control strategies, and the air quality problems. This brief is a progress report on work completed since the last AQMP presentation (August 31, 1977). A draft AQMP is currently scheduled for completion in November 1977 and will be the subject of the last brief.

This brief deals only with the photochemical oxidant problem and alternative strategies for its control. Three topics are discussed in the following sections:

1) Results of additional photochemical oxidant modeling

2) Requirements for meeting the 0.08 ppm federal oxidant standard

3) Considerations for dealing with technical uncertainty

Because of the short time available for preparing this brief, it has not been reviewed by the AQMP-Advisory Committee prior to EMTF receipt. The Advisory Committee will be reviewing this brief at its October 6 meeting. Comments received from them will be recorded, summarized, and presented to EMTF along with staff responses at the October 12 EMTF meeting.

ADDITIONAL LIRAQ AIR QUALITY MODELING RESULTS

The previous brief[1] described how under existing air quality trends, photochemical oxidant would improve from 1975 to 1985. After 1985, oxidant was projected to deteriorate to 1975 levels by the year 2000. Table 1 summarizes the baseline oxidant projections assuming July 26, 1973, prototype meteorology.[2]

Table 1. Bay Area Baseline Photochemical Oxidant Projections (1975-2000)

	1975	1985	2000
Ozone at Highest Station (ppm)	0.13	0.10	0.13
Highest Station	Livermore	Livermore	San Jose
Regionwide High Hour (ppm)	0.17	0.13	0.17
Location of Regional High Hour	6 miles SSE of Livermore	6 miles SSE of Livermore	6 miles SSE of Livermore

Following the baseline analysis, a number of sensitivity runs were conducted to determine how much hydrocarbon and oxides of nitrogen emissions would need to be reduced to meet the 0.08 ppm federal oxidant standard. Table 2 summarizes the results of the sensitivity analyses. As seen from the table, controlling oxides of nitrogen results in higher oxidant formation. This phenomenon is generally recognized as resulting from "ozone quenching"--a situation where oxides of nitrogen actually suppress ozone formation by reacting with ozone to form other oxides of nitrogen and oxygen. The implications to be drawn from the ozone quenching phenomenon are that hydrocarbons should be controlled as stringently as possible, and that care should be exercised in deciding how much control of oxides of nitrogen emissions is appropriate. Two factors are important to consider. The State has a one-hour standard for nitrogen dioxide which is currently exceeded, especially in the South Bay. Thus, some level of control for nitrogen oxides is appropriate to meet the California standard. The recently enacted Clean Air Act of 1977 requires EPA to establish another nitrogen dioxide standard in addition to its 0.05 ppm annual average standard. This new standard must be set within six months and be based on an averaging time not to exceed three hours.

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[1]Leong, E. Y., L. H. Robinson and R. Y. Wada, Air Quality Maintenance Plan Brief No. 3, "Air Quality Problems," August 1977.

[2]For details, see AQMP/Tech Memo 17, "Baseline LIRAQ Air Quality Projections," September 1977.

Table 2. Emission Sensitivity Results (Assuming 1985 Emissions Inventory and July 26, 1973, Meteorology)

% Reduction HC	0	20	40	60	80	40	80	
% Reduction NO	0	0	0	0	0	20	40	
Location of Regional High Hour Ozone	6 Mi SSE Liv.	6 Mi SSE Liv.	6 Mi SE Liv.	6 Mi SE Liv.	Near M.H.	6 Mi SSE Liv.	Near M.H.	Liv.=Livermore M.H.=Montezuma Hills
Regionwide High Hour Ozone (ppm)	.13	.10	.06	.05	.04	.08	.04	
Monitoring Station with Highest Ozone	Liv.	Liv.	Liv.	Liv.	Va.	Liv.	Liv.	Va. =Vallejo Liv.=Livermore
High Hour Ozone at Highest Station (ppm)	.10	.08	.05	.04	.03	.07	.04	

The second key factor in controlling nitrogen oxides is the impact on photochemical oxidants, especially ozone. Laboratory studies of oxidant formation and empirical evidence from Los Angeles and elsewhere indicate that nitric oxide reacts to temporarily suppress ozone formation--the ozone formation is delayed. This means that the level of nitrogen oxides plays an important role in determining where and when the maximum ozone formation will occur. By not controlling nitrogen oxides, it is suspected that the oxidant problem of the Bay area may be transported to a neighboring airshed (e.g. Sacramento or Monterey).

In summary, an appropriate level of control for emissions of nitrogen oxides would be to ensure attainment and maintenance of the California nitrogen dioxide standard. Approximately twenty percent reduction of projected nitrogen oxides emissions for 1985 and 2000 would probably be sufficient. Additional controls of nitrogen oxides beyond these levels should be initiated with care.

Following the sensitivity analysis, two specific comprehensive strategies were analyzed for the year 2000, again assuming July 26, 1973, prototype meteorology. Both strategies simulated a comprehensive control strategy of additional stationary and mobile source controls, transportation controls, and improved land use management. (The eighteen measures described in ABAG's "Progress Report on Draft Environmental Management Plan," September 1977, were all assumed to have been implemented.) The main difference in the strategies analyzed was the degree of nitrogen oxides control. Results of these two strategy runs are shown in Table 3.

Table 3. LIRAQ Analysis of Comprehensive Strategies for 2000 (July 26, 1973 Prototype Meteorology)

	2000 Baseline	Comprehensive Strategy #1 [a]	Comprehensive Strategy #2 [b]
Highest Station Value (ppm)	0.13	0.06	0.06
Highest Station	San Jose	Livermore	Livermore
Regionwide High Value (ppm)	0.17	0.075	0.082
Location of Regionwide High	6 miles SSE of Livermore	6 miles SSE of Livermore	6 miles SSE of Livermore
Individual Station High Values (ppm)			
San Francisco	0.02	0.02	0.02
San Rafael	0.02	0.02	0.02
Pittsburgh	0.05	0.03	0.04
Livermore	0.12(.122)	0.06	0.06
Fremont	0.06	0.02	0.03
San Jose	0.13(.128)	0.04	0.04
Redwood City	0.07	0.03	0.04
Concord	0.06	0.03	0.04
Richmond	0.04	0.02	0.03
Half Moon Bay	0.03	0.03	0.03
San Leandro	0.06	0.03	0.03
Los Gatos	0.07	0.03	0.03
Vallejo	0.04	0.03	0.04

[a] Comprehensive Strategy #1 - 48.5% reduction of hydrocarbons only.
[b] Comprehensive Strategy #2 - 48.5% reduction of hydrocarbons and 19.9% reduction of nitrogen oxides.

The air quality standards established are not to be exceeded more than once per year. Since LIRAQ models only one day's meteorology, statistical procedures must be used to interpret whether or not LIRAQ results will or will not meet the oxidant standard. In air quality jargon, LIRAQ results must be corrected for "worst case" conditions.[3]

The corrections for regionwide high hour values simulated in Table 3 are listed below in Table 4.

Table 4. Projected Regionwide High Hour Oxidant for the Year 2000

	July 26, 1973 Projected High (ppm)	Correction for Worst Case	Correction for Validation	Projected Annual High Hour (ppm)
Baseline 2000	0.17	x 4/3	x 18/17	0.24 (observed)
Comprehensive Strategy #1	0.075	x 4/3	x 18/17	0.106
Comprehensive Strategy #2	0.082	x 4/3	x 18/17	0.116

By extrapolating all of the analysis conducted to date--baseline air quality forecasts, sensitivity analysis for 1985, and effects of implementing a comprehensive strategy in 2000--it is possible to calculate the emission reduction requirements for achieving the 0.08 ppm oxidant standard. The above analysis shows that no more than 450 tons/day of hydrocarbon emissions are allowable if the 0.08 ppm oxidant standard is to be met.[4]

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[3] For further details, see AQMP/Issue Paper 2, "The Air Quality Modeling Process: Accuracy and Related Issues," May 1977, and AQMP/Tech Memo 20, "Procedure for Interpretation of LIRAQ Air Quality Projections," September 1977.

[4] For further details, see AQMP/Tech Memo 18, "LIRAQ Emissions Sensitivity Analysis," September 1977

MEETING THE 0.08 PPM OXIDANT STANDARD

At the September EMTF meeting, the AQMP-Joint Technical Staff was instructed to analyze further what additional measures would be required to demonstrate attainment and maintenance of the oxidant standard. Specifically, consideration was to be given to control measures such as taxes, fuel rationing, energy conservation, and population measures. These additional controls have also become known as the "Oh My God" measures.

This section briefly describes a variety of additional measures which may contribute to reducing hydrocarbon emissions (Table 5). They have not been analyzed (or assessed) to the level of detail as the eighteen measures summarized in the "Progress Report...". The emission reduction estimates provided represent approximations made by ABAG staff and have not been verified. They do represent, however, a plausible range based on the emission inventory data available.

Table 5. Additional AQMP Control Measures and Approximate Reduction Potentials[a]

	1985		2000	
	T/D	(%)	T/D	(%)
Stationary Sources				
• Lower Reid Vapor Pressure	15-30	2-4	20-35	2-3
• Ban Small Gasoline Engines (e.g. Lawnmowers)	10-15	1-2	20-30	2-3
Mobile Sources				
• Catalytic Converter Retrofit ('71-'74 LDV)	1-3	0.1-0.3	0	0
• Evaporative Retrofit (pre-1978)	3-5	0.3-0.6	0	0
Transportation Controls				
• Increased Gas Tax • Area License • Smog Charges • More Stringent Application of Previously-cited Transportation Controls	3-5	0.3-0.6	To be implemented with land use management measures	
Land Use Management				
• More Stringent Application of Land Use Management Measures Previously Cited	Not Estimated		10-15	0.9-1.4

[a]Expressed in tons/day (T/D) hydrocarbon emissions and as a percent (%) of 1985 and 2000 baseline emissions

Table 5. Additional AQMP Control Measures and Approximate Reduction Potentials (Continued)

• Energy Conservation	Negligible and possible negative impact on hydrocarbon emissions
• Fuel Rationing (including gasoline)	Variable impact depending on stringency of application and user groups affected. Obviously, a very direct and potentially effective means of reducing hydrocarbon emissions
• Prohibiting Certain Organic Solvent Use	Variable impact depending on stringency of application. This measure assumes going considerably beyond the use of water-based and high solids content solvents and BACT on organic solvent evaporation
• Population Measures	The baseline air quality projections have assumed 6.1 million people in the region by the year 2000. If the lower population range of 5.4 million were to be realized (e.g. from lower fertility and migration), hydrocarbon emissions are projected to be 59 tons/day less (this represents approximately 5.6% of baseline 2000 emissions).

The amount of hydrocarbon emissions allowable for the Bay Area to meet the oxidant standard is variable and influenced by a number of factors. As previously noted, the level of nitrogen oxides present strongly influences peak oxidant formation. Similarly, the spatial and temporal distribution of emissions is important. Based on the best information available, hydrocarbon emissions of less than 450 tons per day are required to meet the 0.08 ppm oxidant standard. In some instances, depending on nitrogen oxides present and how the hydrocarbons are distributed, substantially less hydrocarbon emissions would be necessary in order to meet the standard.

The additional reductions in hydrocarbon emissions required to meet the oxidant standard in 1985 and 2000 are summarized in Table 6. It has been assumed that the comprehensive strategy previously described is successfully implemented.

Table 6. Hydrocarbon Emission Reductions Required to Achieve the 0.08 PPM Photochemical Oxidant Standard

	1985 (Tons/Day)	2000 (Tons/Day)	
Base Line Emissions	797	1058	
Allowable Hydrocarbon Emissions[a]	< 450	< 450	
Hydrocarbons Remaining after Implementing Comprehensive Strategy	511	604[b]	545[c]
Additional Hydrocarbon Reductions Needed to Meet Standard	> 61	>154[b]	> 95[c]

[a] Varies as a function of oxides of nitrogen emissions and the spatial and temporal distribution of all precursor emissions.

[b] Assumes upper range of population forecast in Series 3 projections--6.1 million people in 2000.

[c] Assumes lower range of population forecast in Series 3 projections--5.4 million people in 2000.

DEALING WITH TECHNICAL UNCERTAINTY

An important factor for making informed planning decisions is understanding the degree of uncertainty in the supporting technical analysis. There are two basic sources of uncertainty in the Air Quality Maintenance Plan: uncertainties related to the projections and those arising from inaccuracies in the data and analysis tools used. Each of these sources should be considered in formulating the AQMP control strategies.

It should also be noted that uncertainties usually occur in two directions: They may result in either underestimates or overestimates depending on the individual point of view.

FORECASTING UNCERTAINTIES

To prepare a long-range plan for attaining and maintaining air quality standards it is necessary to forecast what future air quality is likely to be, as well as what sources will contribute most significantly to future air quality problems. Such a forecast is required by federal regulations. In making these forecasts, a variety of assumptions must be made regarding how the region will grow, how effective existing air pollution control programs will be, and how future resources will be consumed. These assumptions have been documented in various AQMP Tech Memos, Issue Papers, and Projections Technical Advisory Committee (PTAC) Working Papers. Each assumption reflects some judgment, and alternative assumptions are always possible. The forecasting process for AQMP was designed to explicitly identify and discuss such assumptions before completion of the analysis, thus ensuring as much objectivity as possible.

The resulting forecasts indicate the most likely future of air quality in the region under various conditions. It is possible that trends will change or unexpected events will occur which would invalidate the forecasts. This is one reason for establishing a continuing planning program, for which the current AQMP would be an initial effort. In the meantime, decisions made now can and will affect future air quality. Despite the many assumptions which are made, a rigorous, objective forecast is a necessary key element of the AQMP.

ANALYTICAL UNCERTAINTIES

Independent of the difficulties related to forecasting future conditions are uncertainties inherent in the forecasting models. As discussed in AQMP Issue Paper 2,[5] models are used to better understand complex problems such as air pollution. Air quality models always have and will continue to contain inherent imperfections--this is a reflection of practical constraints on data acquisition, computer capacity, and the state of knowledge on the complex processes involved.

Despite the imperfect nature of modeling, the models being used in support of the Air Quality Maintenance Plan are among the most sophisticated and most thoroughly tested models available. Verification tests of model performance have been conducted prior to and as part of the current AQMP effort. In addition, appropriate adjustments have been developed to temper model performance according to measured air quality data and expert judgment.[6] The resulting forecasts are as objective, rigorous, and accurate as possible at this time.

THE BASIS FOR A COMPREHENSIVE APPROACH

In decision-making theory, there are basically three ways to approach the problem of uncertainty: (1) buy time; (2) buy additional information; and (3) buy flexibility as a hedge. A decision to buy time means that no action is taken in the hope that either conditions will change to make the problem go away, or additional information will be acquired which will point to the solution. The difficulty with this approach is that while we are waiting for the solution to materialize, the population of the region is exposed to levels of air pollution that are unhealthy. In addition, certain controls such as retrofits and land use controls are reduced in effectiveness if not implemented in a timely fashion. Lastly, such an approach may mean there is no plan.

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[5] AQMP Issue Paper 2, "The Air Quality Modeling Process: Accuracy and Related Issues," May 1977.

[6] The air quality modeling effort undergoes periodic review by a special modeling committee composed of modeling experts from the Lawrence Livermore Laboratory, California Air Resources Board, Bay Area Air Pollution Control District, Systems Applications Inc., U.S. Environmental Protection Agency, Metropolitan Transportation Commission, and Association of Bay Area Governments.

A decision to buy information presumes that the information to be gained will change the plan recommendations or identify more appropriate solutions. The shortcoming of this approach is that the air pollution problem has many dimensions, only one of which is technical. The political, social, and institutional dimensions are equally as important to the solution as the technical information. The control measures currently being assessed bear a striking resemblance to the control measures recommended for implementation in a study done four years ago.[7] Based on a significantly less sophisticated analysis, the following recommendations for control were made:

- control of gasoline evaporation losses
- organic solvent controls (surface coatings, dry cleaning, and degreasing)
- aircraft emission controls
- mandatory annual inspection and maintenance for light duty vehicles
- catalyst retrofit for earlier model light duty vehicles
- transit service improvements
- coordinated land use and transportation decision-making

That study also concluded that these control measures would not be sufficient to meet the oxidant standard, and identified other less feasible measures which would be necessary, including gasoline rationing. It is apparent that many of the recommended programs have not been implemented for reasons other than the lack of adequate technical analysis.

Previous AQMP briefs have stressed the need for a comprehensive approach to improve air quality. Such an approach is needed precisely because of uncertainties in the analysis as well as uncertainties in forecasting which programs will really work once implemented. In short, a comprehensive strategy is a hedge against uncertainty in addition to having the best chance of success.

A comprehensive strategy is more flexible than a strategy which relies heavily on one control approach (e.g. the technological fix), particularly since it is clear that neither technology alone nor land use and transportation controls alone will provide for attainment of air quality standards. By implementing further controls in all areas, the base of experience in air pollution control is broadened so that additional measures may be identified at some later date. The region also has greater assurance that steady progress toward the goal is being achieved.

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[7] TRW, Inc., "Air Quality Implementation Plan Development for Critical Air Basins: San Francisco Bay Intrastate AQCR," prepared for U.S. Environmental Protection Agency, July 1973.

THE FINAL PRODUCT

Previous briefs have described what the AQMP requirements are and how proposals being considered would satisfy these requirements. Key factors to remember in developing the draft AQMP are once again summarized for EMTF.

THE GOAL OF THE AQMP

The goal of the Air Quality Maintenance Plan is attainment and maintenance of federal and State air quality standards as expeditiously as practicable. The new Clean Air Act of 1977 provides for extensions to 1987 for attainment of the standards based on demonstrated need.

AQMP REQUIREMENTS

It has been assumed throughout the AQMP planning process that time extensions could be granted provided there was demonstration of: 1) good faith efforts by State, regional, and local governments, and 2) steady progress towards the goal.

THE NEED FOR A COMPREHENSIVE STRATEGY

As described in this brief, a comprehensive strategy serves in part as a hedge against uncertainty. Furthermore, based on the analysis to date (and similar studies conducted years ago) a comprehensive strategy is needed if the region is to meet the air quality standards established.

PROGRESS AND SCHEDULE

A number of additional analyses are currently being conducted for input to the plan. These analyses are as follows:

- The impacts of the control strategies on air quality in the Northern Bay Area counties of Napa, Sonoma, Marin, and Solano. The analysis will be conducted by shifting the LIRAQ grid northward on the prototype day July 26, 1973.

- The affects of the control strategies on a second prototype day with different meteorological conditions will be tested.

- The assessment of control strategy costs, benefits, and impacts are being prepared in final form for review.

Although some delays have been encountered in preparing this information, the draft Air Quality Maintenance Plan is scheduled for completion in November. At that time, additional work which is needed in the continuing planning process will be identified and proposed.

ADVISORY COMMITTEE COMMENTS

Due to the tight time constraints, the AQMP Advisory Committee has not had an opportunity to review this brief prior to EMTF receipt of it. The Advisory Committee is meeting on October 6 when this brief will be presented and reviewed. Comments provided by the Advisory Committee will be recorded and summarized, along with staff responses to the comments. A summary of this meeting will be provided to EMTF at its October 12 meeting.